Experiment 4

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Branch: BE-IT **Section/Group: 22BET_IOT_701/A**
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Subject Name: Advanced Programming Lab-2 **Subject Code: 22ITP-351**

Problem 1. Given a string s, return the longest substring of s that is nice. If there are multiple, return the substring of the earliest occurrence. If there are none, return an empty string.

Algorithm:

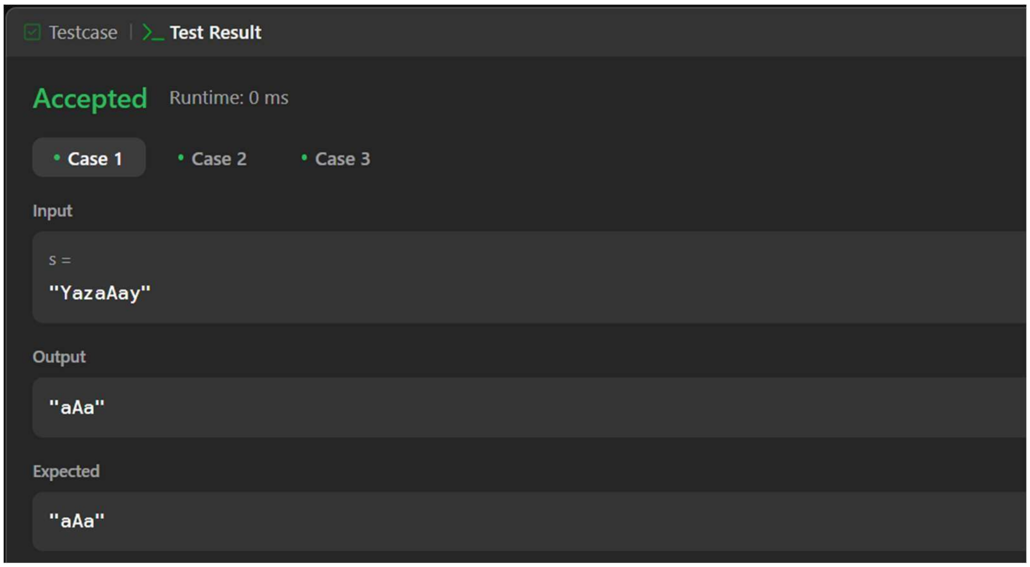
1. **Base Case:**
- If the length of s is less than 2, return an empty string ("") because a single character cannot be "nice".
2. **Create a Set of Characters in s:**
- Store all characters of s in a hash set for quick lookup.
3. **Find a Split Point:**
- Traverse through s. If a character appears in only one case (i.e., either uppercase or lowercase but not both), this means the substring cannot be nice.
- Use this character as a **split point** and break s into two substrings:
  - left = s [0: i]
  - right = s [i+1:]
- Recursively find the longest "nice" substring in both parts.
4. **Compare Substrings:**
- Return the longer of the two substrings found in step 3.
5. **If No Split Occurs:**
- If no character was found that requires splitting, return s itself as it is already "nice".

Code:

```
class Solution {
public:
    string longestNiceSubstring(string s) {
        if (s.length() < 2) return "";

    unordered_set<char> charSet(s.begin(), s.end());

    for (int i = 0; i < s.length(); i++) {
        if (charSet.count(tolower(s[i])) && charSet.count(toupper(s[i]))) {
            continue;
        }

        string left = longestNiceSubstring(s.substr(0, i));
        string right = longestNiceSubstring(s.substr(i + 1));
```

```
            return (left.length() >= right.length()) ? left : right;
        }

        return s;
        }
    };
```

Output:



Problem 2. Reverse bits of a given 32 bits unsigned integer.

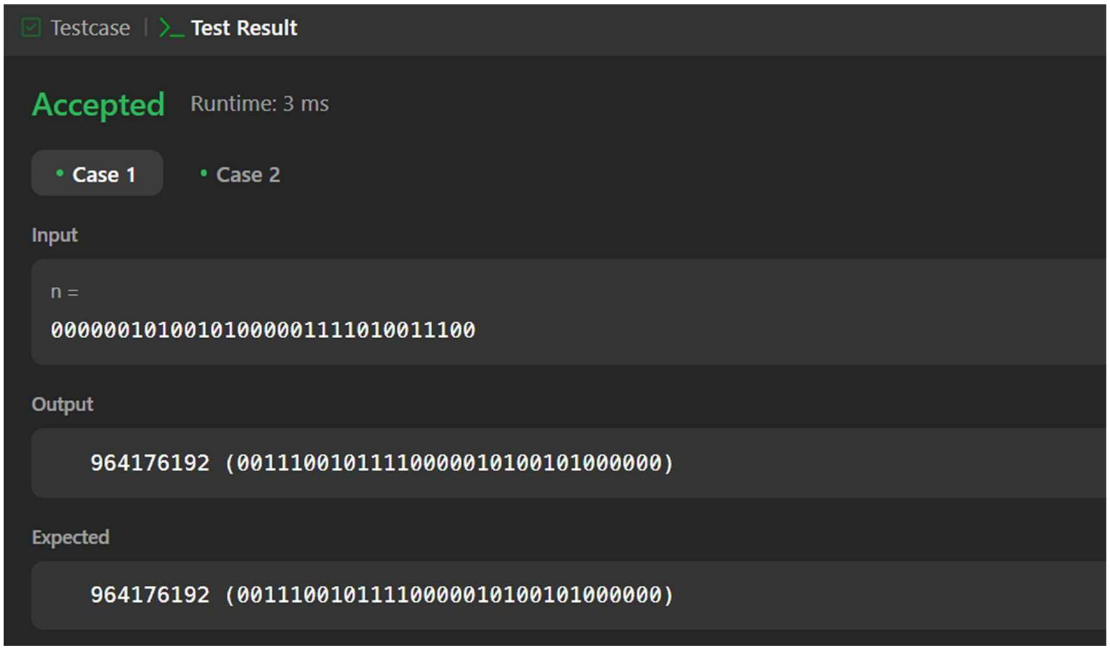
Algorithm:

1. Initialize result to 0
   - This variable will store the reversed bits.
2. Iterate 32 times (since it's a 32-bit integer)
   - Extract the least significant bit (LSB) of n using n & 1.
   - Shift result left by 1 to make space for the new bit.
   - Add the extracted bit to result.
   - Right shift n by 1 to process the next bit.
3. Return result
   - The final value of result contains the reversed bit sequence.

Code:

```
class Solution {
public:
    uint32_t reverseBits(uint32_t n) {
        uint32_t result = 0;
        for (int i = 0; i < 32; i++) {
            result = (result << 1) | (n & 1);
            n >>= 1;
        }
        return result;
    }
};
```

Output:



Problem 3. Given a positive integer n, write a function that returns the number of set bits in its binary representation (also known as the Hamming weight).

Algorithm:

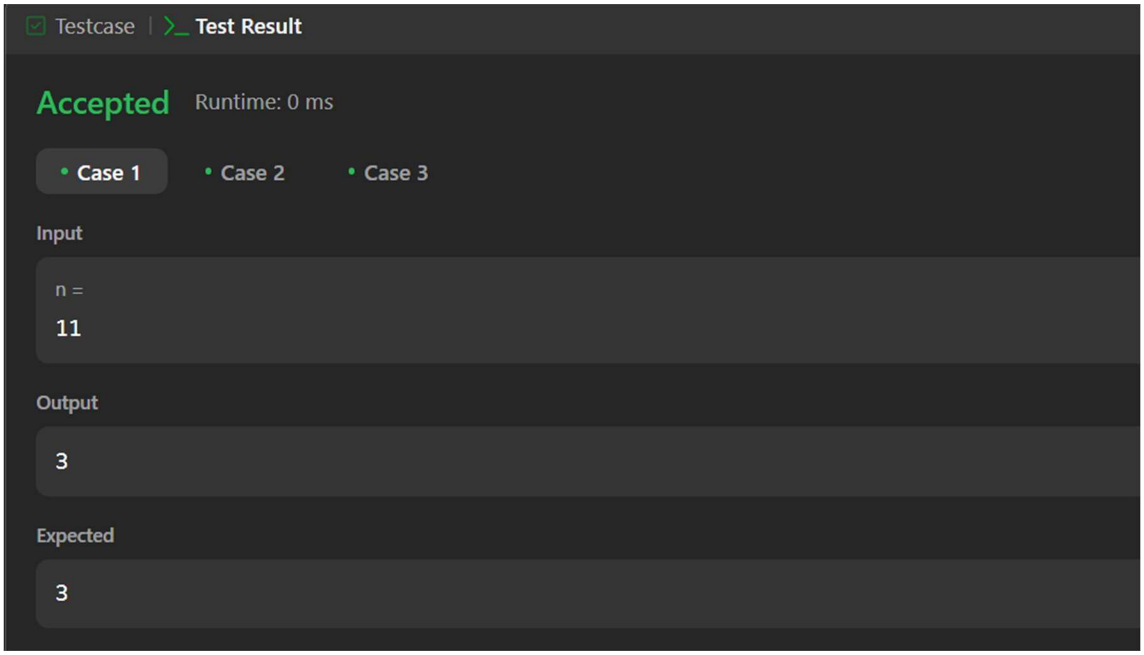
Steps

1. Initialize count = 0 to store the number of 1 bits.
2. Iterate through all 32 bits of the integer:
   - Check if the last bit is 1 using (n & 1).
   - If true, increment count.
   - Right shift n (n = n >> 1) to check the next bit.
3. Return count after processing all bits.

Code:

```
class Solution {
    public:
        int hammingWeight(int n) {
            int count = 0;
            while (n != 0) {
                count += (n & 1);
                n >>= 1;
            }
            return count;
        }
};
```

Output:



Problem 4. Given an integer array nums, find the subarray with the largest sum, and return *its sum*.

Algorithm:

1. **Initialize Variables**
   - maxsum = nums[0] → Stores the maximum subarray sum found so far.
   - currsum = 0 → Tracks the sum of the current subarray.
2. **Iterate Through the Array**
   - If currsum becomes negative, reset it to 0 (since a negative sum reduces the potential maximum).
   - Add the current element num to currsum.
   - Update maxsum = max(maxsum, currsum).

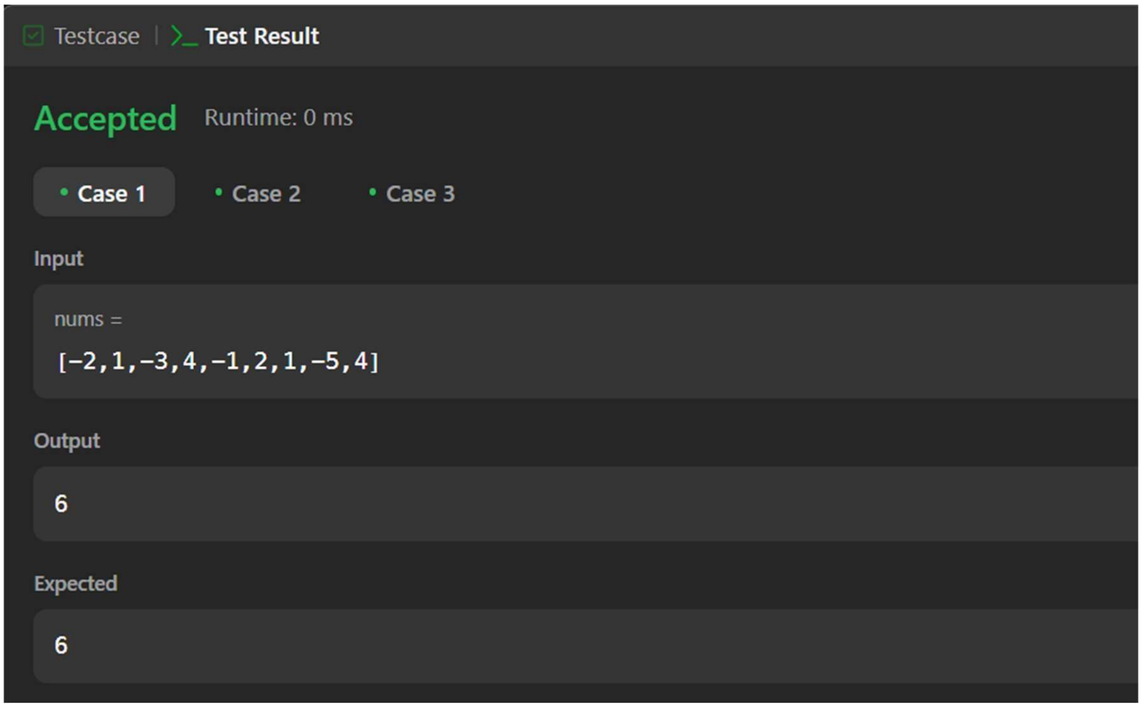
4. **Return maxsum**, which stores the maximum subarray sum.

Code:

```
class Solution {
public:
    int maxSubArray(vector<int>& nums) {
        int maxsum = nums[0];
        int currsum = 0;

    for (int num : nums) {

        if (currsum < 0) {
            cursum = 0;
        }

        currsum += num;
```

```
        maxsum = max(maxsum, currsum);
    }

    return maxsum;
    }
};
```

Output:



Problem 5. Write an efficient algorithm that searches for a value target in an m x n integer matrix. This matrix has the following properties:

- Integers in each row are sorted in ascending from left to right.
- Integers in each column are sorted in ascending from top to bottom.

Algorithm:

1. Define the Search Space
   - Treat the matrix as a flattened 1D array of size m * n.
   - Define search boundaries:
     - left = 0 (first element)
     - right = (m * n) - 1 (last element)
2. Perform Binary Search
   - Compute the middle index:
     - mid = (left + right) / 2
   - Convert this 1D index into a 2D index:
     - row = mid / n
     - col = mid % n
   - Compare matrix[row][col] with target:
     - If equal, return true.
     - If less than target, search the right half (left = mid + 1).

   - If greater than target, search the left half (right = mid - 1).
3. Return false if target is not found.

Code:

```
class Solution {
public:
    bool searchMatrix(vector<vector<int>>& matrix, int target) {
      if (matrix.empty() || matrix[0].empty()) return false;

        int rows = matrix.size();
        int cols = matrix[0].size();
        int left = 0, right = rows * cols - 1;

        while (left <= right) {
            int mid = left + (right - left) / 2;
            int row = mid / cols;
            int col = mid % cols;

            if (matrix[row][col] == target)
                return true;
            else if (matrix[row][col] < target)
                left = mid + 1;
            else
                right = mid - 1;
        }
        return false;
    }
};
```

Output:

Problem 6. Write an efficient algorithm that searches for a value target in an m x n integer matrix matrix. This matrix has the following properties:

- Integers in each row are sorted in ascending from left to right.
- Integers in each column are sorted in ascending from top to bottom.

Algorithm:

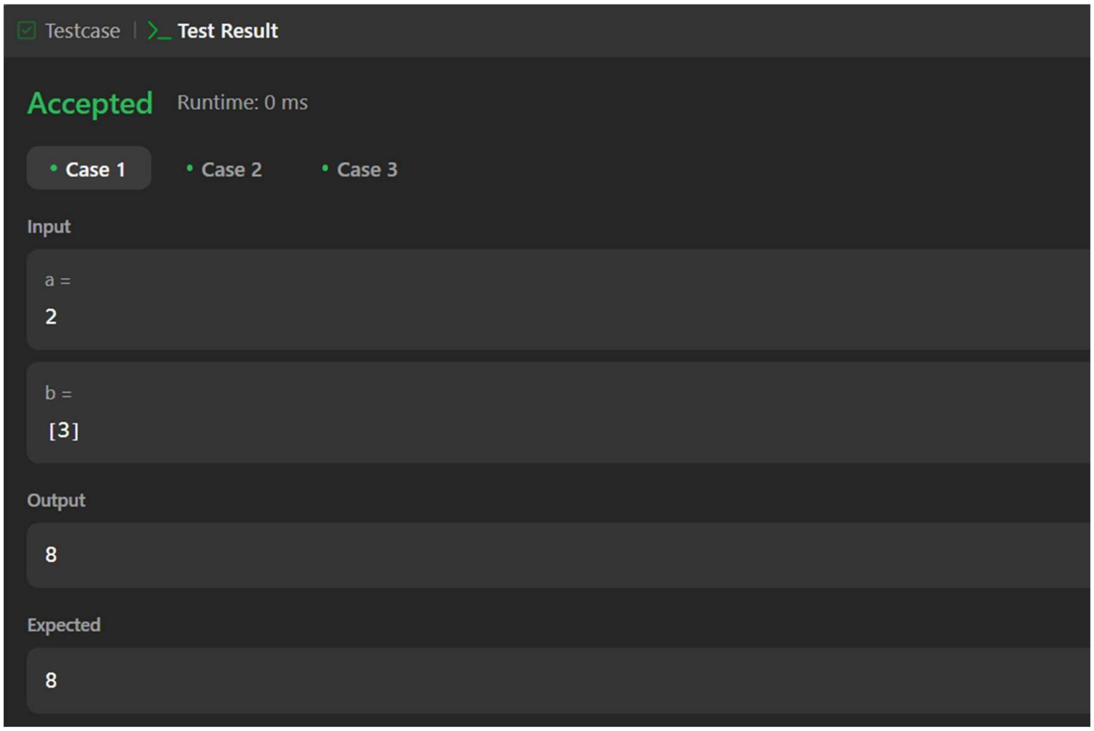
1. **Define a helper function modPow(a, exp, mod)** that computes:
   (aexpmod mod) (a^{exp} \mod mod) (aexpmodmod)
   efficiently using **fast exponentiation**.
2. **Process the exponent list b using recursion**:

- Extract the **last digit** from b (lastDigit = b.pop_back()).
- Compute: part1= (modPow(a, lastDigit,1337))part1 = (modPow(a, lastDigit, 1337))part1=(modPow(a,lastDigit,1337)) part2=(modPow(superPow(a,b),10,1337))part2 = (modPow(superPow(a, b), 10, 1337))part2=(modPow(superPow(a,b),10,1337))
- Combine results: result=(part1×part2) mod 1337result = (part1 \times part2) \mod 1337result=(part1×part2) mod1337

Code:

```
class Solution {
public:
    const int MOD = 1337;
    int modPow(int a, int exp, int mod) {
        int result = 1;
        a %= mod;
        while (exp > 0) {
            if (exp % 2 == 1)
                result = (result * a) % mod;
            a = (a * a) % mod;
            exp /= 2;
        }
        return result;
    }

    int superPow(int a, vector<int>& b) {
        if (b.empty()) return 1;

        int lastDigit = b.back();
        b.pop_back();

        int part1 = modPow(a, lastDigit, MOD);
        int part2 = modPow(superPow(a, b), 10, MOD);

        return (part1 * part2) % MOD;
    }
};
```

Output:



Problem 7. Given the integer n, return *any* ***beautiful*** *array* nums *of length* n. There will be at least one valid answer for the given n.

Algorithm:

1. Start with **base case**: n = 1 → {1}.
2. Recursively generate two sequences:

- **Odd values**: 2 * x - 1 (from beautifulArray(n/2))
- **Even values**: 2 * x (from beautifulArray(n/2))

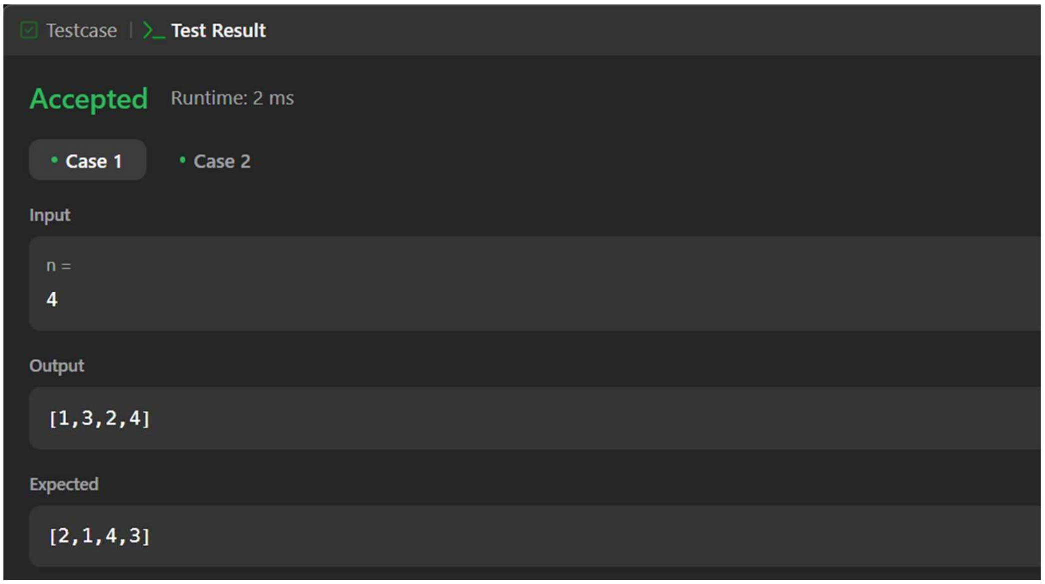
3. Combine the two sequences to maintain the required properties.

Code:

```
class Solution {
public:
    vector<int> beautifulArray(int n) {
        vector<int> result = {1};
        while (result.size() < n) {
            vector<int> temp;
            for (int num : result) {
                if (2 * num - 1 <= n)
                    temp.push_back(2 * num - 1);
            }
            for (int num : result) {
                if (2 * num <= n)
                    temp.push_back(2 * num);
            }
```

```
            result = temp;
        }
        return result;
    }
};
```

Output:



Problem 8. Given a positive integer n, write a function that returns the number of set bits in its binary representation (also known as the Hamming weight).

Algorithm:

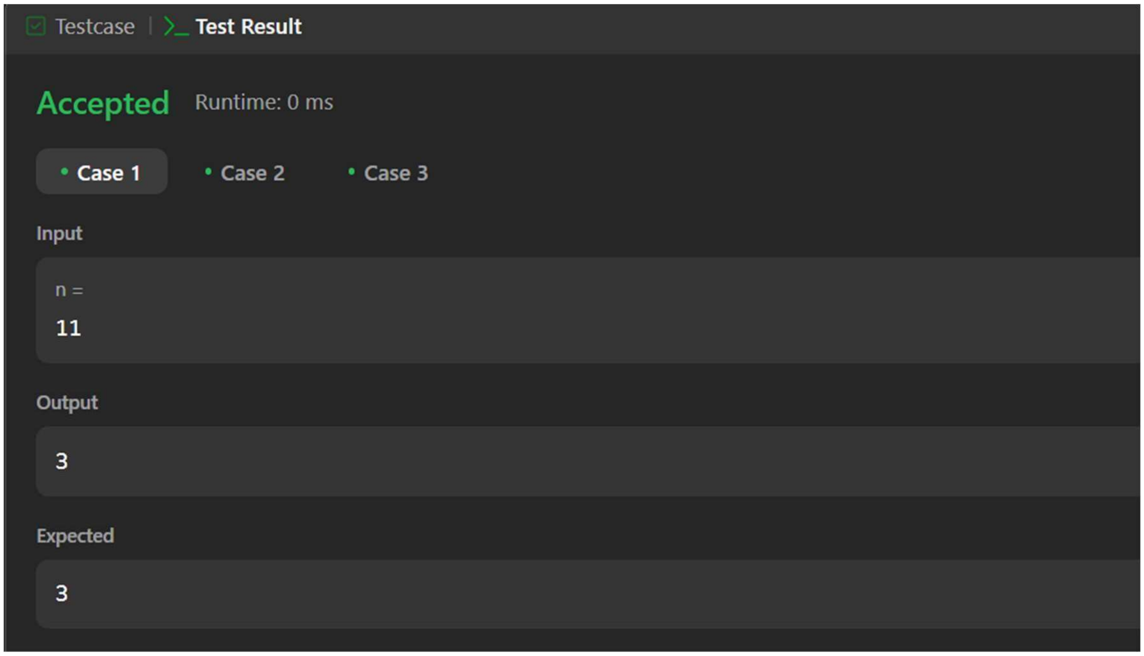
Steps

5. Initialize count = 0 to store the number of 1 bits.
6. Iterate through all 32 bits of the integer:
   - Check if the last bit is 1 using (n & 1).
   - If true, increment count.
   - Right shift n (n = n >> 1) to check the next bit.
7. Return count after processing all bits.

Code:

```
class Solution {
public:
    int hammingWeight(int n) {
        int count = 0;
        while (n != 0) {
            count += (n & 1);
            n >>= 1;
        }
        return count;
    }
};
```

Output:



Problem 9. Given an integer array nums, find the subarray with the largest sum, and return *its sum*.

Algorithm:

1. **Initialize Variables**
   - maxsum = nums[0] → Stores the maximum subarray sum found so far.
   - cursum = 0 → Tracks the sum of the current subarray.
2. **Iterate Through the Array**
   - If cursum becomes negative, reset it to 0 (since a negative sum reduces the potential maximum).
   - Add the current element num to cursum.
   - Update maxsum = max(maxsum, cursum).

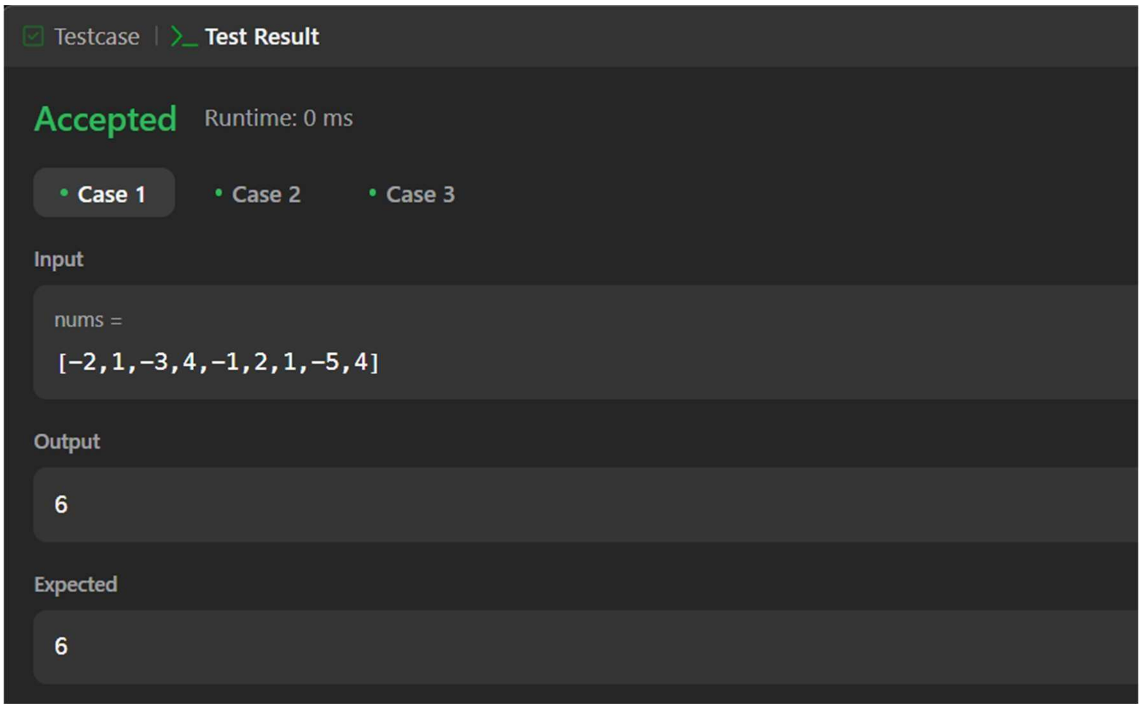
8. **Return maxsum**, which stores the maximum subarray sum.

Code:

```
class Solution {
public:
    int maxSubArray(vector<int>& nums) {
        int maxsum = nums[0];
        int cursum = 0;

    for (int num : nums) {

        if (cursum < 0) {
            cursum = 0;
        }

        cursum += num;
```

```
            maxsum = max(maxsum, currsum);
        }

        return maxsum;
        }
    };
```

Output:



Problem 10. Write an efficient algorithm that searches for a value target in an m x n integer matrix. This matrix has the following properties:

- Integers in each row are sorted in ascending from left to right.
- Integers in each column are sorted in ascending from top to bottom.

Algorithm:

1. Define the Search Space
   - Treat the matrix as a flattened 1D array of size m * n.
   - Define search boundaries:
     - left = 0 (first element)
     - right = (m * n) - 1 (last element)
2. Perform Binary Search
   - Compute the middle index:
     - mid = (left + right) / 2
   - Convert this 1D index into a 2D index:
     - row = mid / n

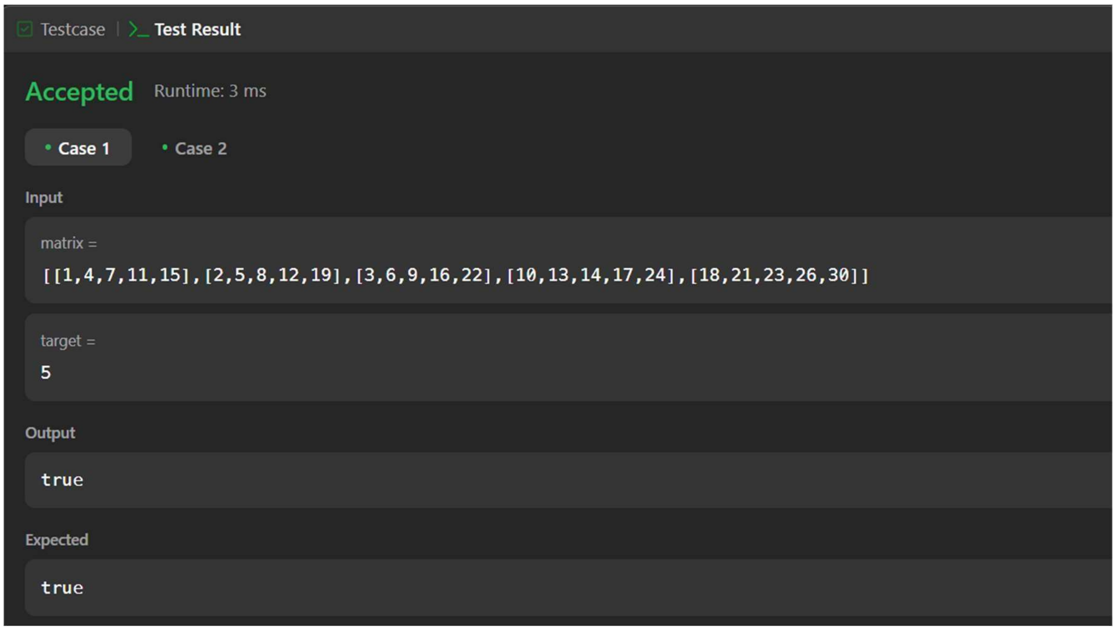
  - col = mid % n
- Compare matrix[row][col] with target:
  - If equal, return true.
  - If less than target, search the right half (left = mid + 1).
  - If greater than target, search the left half (right = mid - 1).

3. Return false if target is not found.

Code:

```
class Solution {
public:

    bool searchMatrix(vector<vector<int>>& matrix, int target) {
      if (matrix.empty() || matrix[0].empty()) return false;

        int rows = matrix.size();
        int cols = matrix[0].size();
        int left = 0, right = rows * cols - 1;

        while (left <= right) {
            int mid = left + (right - left) / 2;
            int row = mid / cols;
            int col = mid % cols;

            if (matrix[row][col] == target)
                return true;
            else if (matrix[row][col] < target)
                left = mid + 1;
            else
                right = mid - 1;
        }
        return false;
    }
};
```

Output:


Testcase
Test Result
Accepted
Runtime: 3 ms
Case 1
Case 2
Input
matrix =
[[1,4,7,11,15],[2,5,8,12,19],[3,6,9,16,22],[10,13,14,17,24],[18,21,23,26,30]]
target =
5
Output
true
Expected
true