Winter Domain Camp

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Day 2

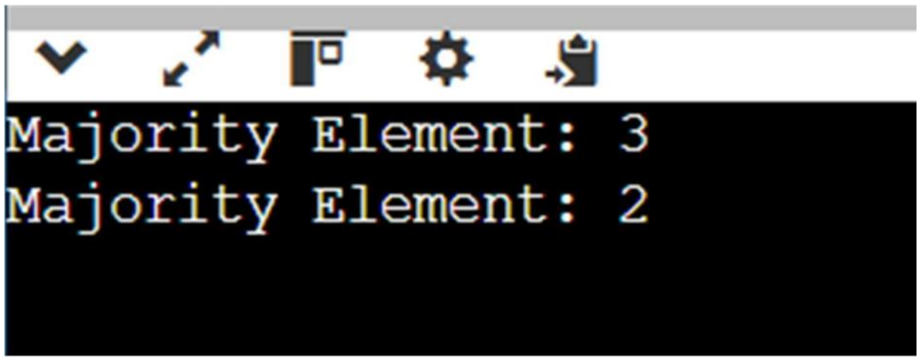
Problem 1: Majority Elements

Given an array nums of size n, return the majority element. The majority element is the element that appears more than ⌊n / 2⌋ times. You may assume that the majority element always exists in the array.

Solution :

```
        #include <iostream>
        #include <vector>

        int majorityElement(const std::vector<int>& nums) {
int candidate = 0, count = 0;         // Phase 1: Find the
candidate         for (int num : nums) {         if (count == 0) {
candidate = num;             count = 1;
        } else if (num == candidate) {
count++;         } else {             count--;
        }
        }

    // Phase 2: Verify the candidate (Optional since problem guarantees majority
element)      count = 0;      for (int num : nums) {      if (num == candidate) {
count++;
        }
    }

    if (count > nums.size() / 2) {
return candidate;
}

throw std::runtime_error("No majority element found.");
 }

 int main() {     std::vector<int> nums = {2, 2,
 1, 1, 1, 2, 2};     try {
        std::cout << "Majority Element: " << majorityElement(nums) << std::endl;
    } catch (const std::exception& e) {
 std::cerr << e.what() << std::endl;
    }
 return 0;
 }
```

Output:



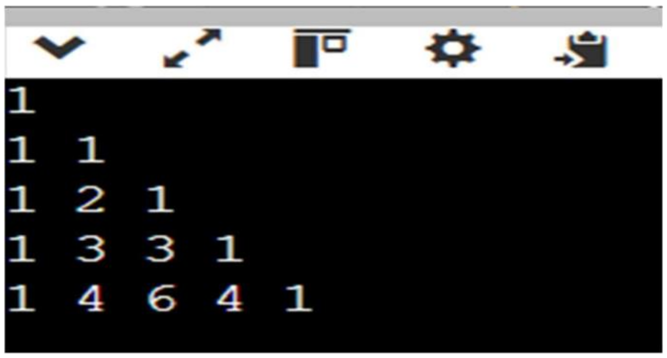
```
Majority Element: 3
Majority Element: 2
```

Problem 2: Pascal's Triangle
Given an integer numRows, return the first numRows of Pascal's triangle. In Pascal's triangle, each number is the sum of the two numbers directly above it

Solution:

```
#include <iostream>
#include <vector>
std::vector<std::vector<int>>                generate(int                numRows)                {
std::vector<std::vector<int>> triangle(numRows);     for (int i = 0; i < numRows; ++i)
{         triangle[i].resize(i + 1, 1);         for (int j = 1; j < i; ++j) {            triangle[i][j]
= triangle[i - 1][j - 1] + triangle[i - 1][j];
        }}     return triangle;} int main() {     int
numRows = 5; // Example input     auto result =
generate(numRows);     for (const auto& row :
result) {        for (int num : row) std::cout <<
num << " ";        std::cout << "\n";}     return
0;}
```

Output:



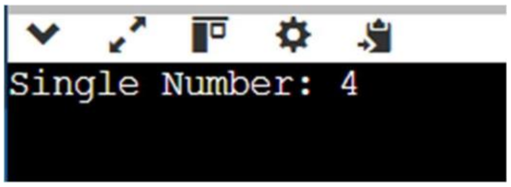
```
1
1 1
1 2 1
1 3 3 1
1 4 6 4 1
```

Problem 3: Single Number

Given a non-empty array of integers nums, every element appears twice except for one. Find that single one. You must implement a solution with a linear runtime complexity and use only constant extra space.
Solution:

```
#include <iostream>
#include <vector>

int singleNumber(const std::vector<int>& nums)
{     int result = 0;     for (int num : nums) {
result ^= num;
    }     return
result; }

int main() {     std::vector<int> nums = {4, 1, 2, 1, 2}; // Example input
std::cout << "Single Number: " << singleNumber(nums) << std::endl;
return 0;
}
```

Output:



```
Single Number: 4
```

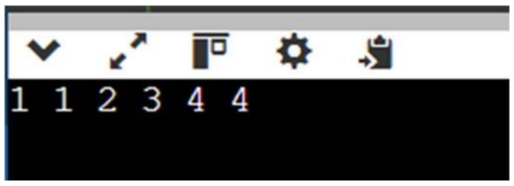
Problem 4: Merge Two Sorted Lists
You are given the heads of two sorted linked lists list1 and list2. Merge the two lists into one sorted list. The list should be made by splicing together the nodes of the first two lists. Return the head of the merged linked list.

Solution:

```
#include <iostream>

struct ListNode {
    int val;
    ListNode* next;
    ListNode(int x) : val(x), next(nullptr) {}
};

ListNode* mergeTwoLists(ListNode* list1, ListNode* list2) {
if (!list1) return list2;     if (!list2) return list1;     if (list1->val
< list2->val) {        list1->next = mergeTwoLists(list1->next,
list2);        return list1;
    } else {
        list2->next = mergeTwoLists(list1, list2->next);
return list2;
    }
}

void printList(ListNode* head) {
while (head) {        std::cout <<
head->val << " ";        head =
head->next;
```

```
    }
}

int main() {
    ListNode* list1 = new ListNode(1);     list1-
>next = new ListNode(2);     list1->next->next =
new ListNode(4);

    ListNode* list2 = new ListNode(1);     list2-
>next = new ListNode(3);     list2->next->next =
new ListNode(4);

    ListNode* mergedList = mergeTwoLists(list1, list2);
printList(mergedList);

    return 0;
}
```

Output:



```
1 1 2 3 4 4
```

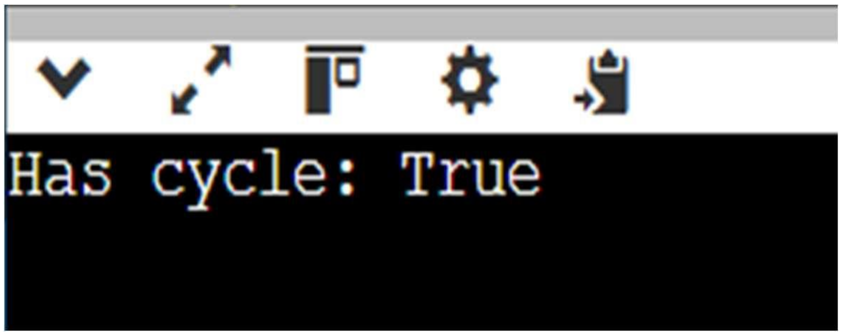
Problem 5: Linked List Cycle.

Given head, the head of a linked list, determine if the linked list has a cycle in it. There is a cycle in a linked list if there is some node in the list that can be reached again by continuously following the next pointer. Internally, pos is used to denote the index of the node that tail's next pointer is connected to. Note that pos is not passed as a parameter. Return true if there is a cycle in the linked list. Otherwise, return false.

Solution:

```
#include <iostream>

struct ListNode {
    int val;
    ListNode* next;
    ListNode(int x) : val(x), next(nullptr) {}
};

bool hasCycle(ListNode* head) {
if (!head) return false;
    ListNode *slow = head, *fast = head;

    while (fast && fast->next) {
        slow = slow->next;            // Move slow pointer by 1 step
fast = fast->next->next;      // Move fast pointer by 2 steps

        if (slow == fast) {           // Cycle
detected            return true;}
}     return false;
// No cycle}
 int main() {
    // Example 1: Creating a cycle in the list

   ListNode* head = new ListNode(3);

    head->next = new ListNode(2);

    head->next->next = new ListNode(0);

  head->next->next->next = new ListNode(-4);

  head->next->next->next->next = head->next;

// Cycle starts at node with value 2
std::cout << "Has cycle: " << (hasCycle(head) ? "True" : "False") << std::endl;

    return 0;
}
```

Output:



```
Has cycle: True
```

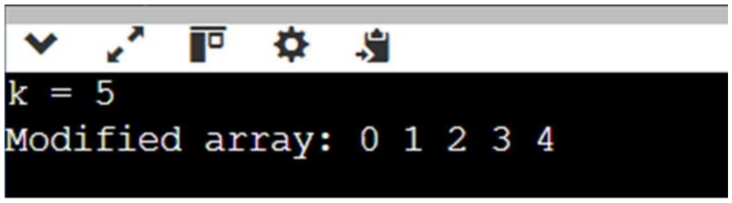
Problem 6: Remove Element

Given an integer array nums sorted in non-decreasing order, remove the duplicates in-place such that each unique element appears only once. The relative order of the elements should be kept the same. Then return the number of unique elements in nums. Consider the number of unique elements of nums to be k, to get accepted, you need to do the following things: Change the array nums such that the first k elements of nums contain the unique elements in the order they were present in nums initially. The remaining elements of nums are not important as well as the size of nums. Return k.

Solution:

```
#include <iostream>
#include <vector>

int removeDuplicates(std::vector<int>& nums) {
   if (nums.empty()) return 0;

   int k = 1;  // Pointer for the next unique element     for (int i = 1; i <
nums.size(); ++i) {         if (nums[i] != nums[i - 1]) {             nums[k++] =
nums[i];  // Move the unique element to the front}}     return k;  // Number of
unique elements} int main() {     std::vector<int> nums = {0,0,1,1,1,2,2,3,3,4};
int k = removeDuplicates(nums);

   std::cout << "k = " << k << std::endl;
std::cout << "Modified array: ";     for (int i =
0; i < k; ++i) {
      std::cout << nums[i] << " ";
   }
   std::cout << std::endl;
   return 0;}
```

Output:



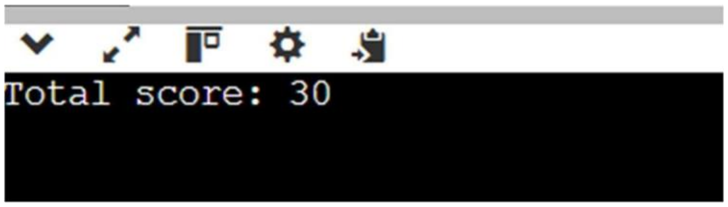
```
k = 5
Modified array: 0 1 2 3 4
```

Problem 7: Baseball Game :

You are keeping the scores for a baseball game with strange rules. At the beginning of the game, you start with an empty record. You are given a list of strings operations, where operations[i] is the ith operation you must apply to the record and is one of the following: An integer x. Record a new score of x. '+'. Record a new score that is the sum of the previous two scores. 'D'. Record a new score that is the double of the previous score. 'C'. Invalidate the previous score, removing it from the record. Return the sum of all the scores on the record after applying all the operations. The test cases are generated such that the answer and all intermediate calculations fit in a 32-bit integer and that all operations are valid.

Solution:

```
#include <iostream>
#include <vector>
#include <string>

int calPoints(std::vector<std::string>& ops) {
std::vector<int> record;     for (const auto& op :
ops) {
        if (op == "C") {            record.pop_back();  //
Remove the last score
        } else if (op == "D") {
            record.push_back(2 * record.back());  // Double the last score
        } else if (op == "+") {
            record.push_back(record[record.size() - 1] + record[record.size() - 2]);  //
Sum of last two scores
        } else {
            record.push_back(std::stoi(op));  // Add the integer score
        }
    }

    int total = 0;     for (int score :
record) {        total += score;
    }

    return total;
}

int main() {
    std::vector<std::string> ops = {"5","2","C","D","+"};
    std::cout << "Total score: " << calPoints(ops) << std::endl;  // Output: 30    return
0; }Output:
```

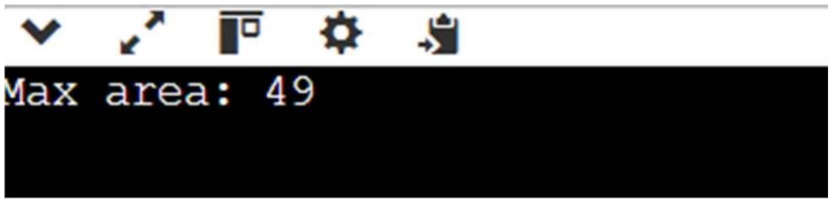


```
Total score: 30
```

Problem 8: Container With Most Water
You are given an integer array height of length n. There are n vertical lines drawn such that the two endpoints of the ith line are (i, 0) and (i, height[i]). Find two lines that together with the x-axis form a container, such that the container contains the most water. Return the maximum amount of water a container can store.

Solution:

```
#include <iostream>
#include <vector>

int maxArea(std::vector<int>& height) {
    int left = 0, right = height.size() - 1, maxArea = 0;

    while (left < right) {         int
width = right - left;
        int h = std::min(height[left], height[right]);
        maxArea = std::max(maxArea, width * h);

        if (height[left] < height[right]) {
            ++left;
        } else {
            --right;
        }
    }

    return maxArea;
}

int main() {
    std::vector<int> height = {1,8,6,2,5,4,8,3,7};     std::cout << "Max area: " <<
maxArea(height) << std::endl;  // Output: 49     return 0;
} Output:
```



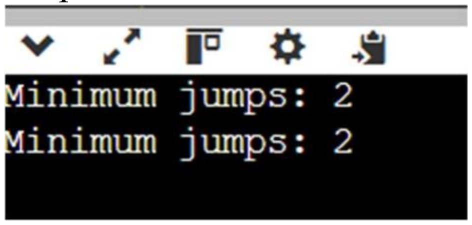
```
Max area: 49
```

Problem 9: Jump Game II
You are given a 0-indexed array of integers nums of length n. You are initially positioned at nums[0]. Each element nums[i] represents the maximum length of a forward jump from index i. In other words, if you are at nums[i], you can jump to any nums[i + j] where: 0 <= j <= nums[i] and i + j < n Return the minimum number of jumps to reach nums[n - 1]. The test cases are generated such that you can reach nums[n - 1].

Solution:

```
#include <iostream>
#include <vector>

int jump(std::vector<int>& nums) {
    int n = nums.size();     int jumps = 0, farthest = 0,
currentEnd = 0;

    for (int i = 0; i < n - 1; ++i) {        farthest = std::max(farthest, i + nums[i]);  // Update
the farthest point we can reach

        if (i == currentEnd) {
            jumps++;           // We make a jump when we reach the current end
currentEnd = farthest;  // Move to the farthest point we can reach

            if (currentEnd >= n - 1) break;  // If we can reach the end, stop
        }
    }

    return jumps;
}

int main() {
    std::vector<int> nums1 = {2,3,1,1,4};     std::cout << "Minimum jumps: " <<
jump(nums1) << std::endl;  // Output: 2

    std::vector<int> nums2 = {2,3,0,1,4};     std::cout << "Minimum jumps: " <<
jump(nums2) << std::endl;  // Output: 2

    return 0;
}
```

Output:



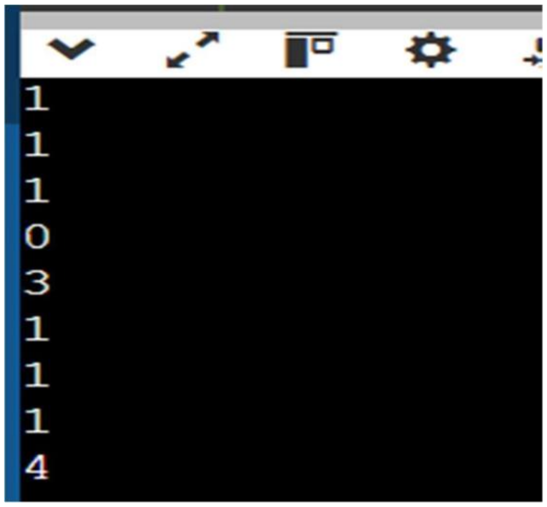
```
Minimum jumps: 2
Minimum jumps: 2
```

Problem 10:   Design Circular Queue
Calculate the sum of the digits of a given number n. For example, for the number 12345, the sum of the digits is 1+2+3+4+5=15. To solve this, you will need to extract each digit from the number and calculate the total sum.

Solution:

```
#include <iostream> #include
<vector> class
MyCircularQueue { private:
    std::vector<int> queue;     int front,
rear, size, capacity; public:
    MyCircularQueue(int k) : queue(k), front(-1), rear(-1), size(0), capacity(k) {}
bool enQueue(int value) {         if (size == capacity) return false;         if (size == 0)
front = 0;         rear = (rear + 1) % capacity;         queue[rear] = value;
        size++;         return
true;}     bool deQueue()
{         if (size == 0)
return false;        if (front
== rear) front = rear = -1;
       else front = (front + 1) % capacity;        size--;        return
true;}    int Front() {        return size == 0 ? -1 :
queue[front];}    int Rear() {        return size == 0 ? -1 :
queue[rear];}    bool isEmpty() {        return size == 0;}
bool isFull() {        return size == capacity;}}; int main() {
MyCircularQueue q(3);     std::cout << q.enQueue(1) <<
std::endl;  // True     std::cout << q.enQueue(2) << std::endl;  //
True     std::cout << q.enQueue(3) << std::endl;  // True
std::cout << q.enQueue(4) << std::endl;  // False (full)
std::cout << q.Rear() << std::endl;      // 3     std::cout <<
q.isFull() << std::endl;    // True     std::cout << q.deQueue()
<< std::endl;   // True     std::cout << q.enQueue(4) <<
std::endl;  // True     std::cout << q.Rear() << std::endl;      // 4
   return 0;}
```

Output:



```
1
1
1
0
3
1
1
1
4
```

Problem 11: Cherry Pickup II

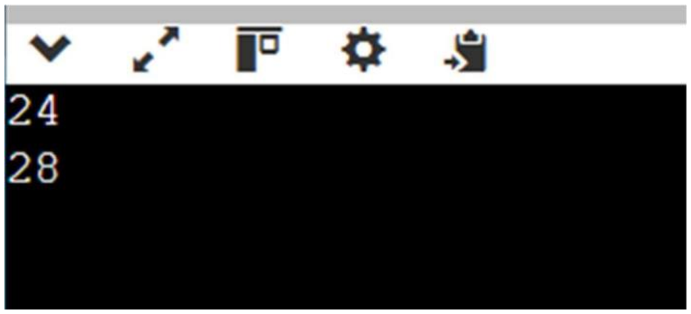
You are given a rows x cols matrix grid representing a field of cherries where grid[i][j] represents the number of cherries that you can collect from the (i, j) cell. You have two robots that can collect cherries for you: Robot #1 is located at the top-left corner (0, 0), and Robot #2 is located at the top-right corner (0, cols - 1). Return the maximum number of cherries collection using both robots by following the rules below: From a cell (i, j), robots can move to cell (i + 1, j - 1), (i + 1, j), or (i + 1, j + 1). When any robot passes through a cell, It picks up all cherries, and the cell becomes an empty cell. When both robots stay in the same cell, only one takes the cherries. Both robots cannot move outside of the grid at any moment. Both robots should reach the bottom row in grid.

Solution:

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

class Solution { public:
   int cherryPickup(vector<vector<int>>& grid) {        int rows = grid.size(),
cols = grid[0].size();        vector<vector<vector<int>>> dp(rows,
vector<vector<int>>(cols, vector<int>(cols, -1)));        return dfs(0, 0, cols -
1, grid, dp);
   }

private:
   int dfs(int row, int col1, int col2, vector<vector<int>>& grid,
vector<vector<vector<int>>>& dp) {
       int rows = grid.size(), cols = grid[0].size();
       if (col1 < 0 || col2 < 0 || col1 >= cols || col2 >= cols) return 0;        if
(dp[row][col1][col2] != -1) return dp[row][col1][col2];

       int cherries = grid[row][col1];        if (col1 !=
col2) cherries += grid[row][col2];        if (row < rows -
1) {            int maxCherries = 0;
           for (int d1 = -1; d1 <= 1; d1++) {
               for (int d2 = -1; d2 <= 1; d2++) {              maxCherries = max(maxCherries,
dfs(row + 1, col1 + d1, col2 + d2, grid, dp));
               }
           }
           cherries += maxCherries;
       }
       return dp[row][col1][col2] = cherries;
   }
         };
```

```
int main() {     Solution sol;
    vector<vector<int>> grid1 = {{3,1,1},{2,5,1},{1,5,5},{2,1,1}};     cout <<
sol.cherryPickup(grid1) << endl; // Output: 24

    vector<vector<int>> grid2 =
{{1,0,0,0,0,0,1},{2,0,0,0,0,3,0},{2,0,9,0,0,0,0},{0,3,0,5,4,0,0},{1,0,2,3,0,0,6}};
cout << sol.cherryPickup(grid2) << endl; // Output: 28     return 0;
}
```

Output:



```
24
28
```

Problem 12: Maximum Number of Darts Inside of a Circular Dartboard

Alice is throwing n darts on a very large wall. You are given an array darts where darts[i] = [xi, yi] is the position of the ith dart that Alice threw on the wall. Bob knows the positions of the n darts on the wall. He wants to place a dartboard of radius r on the wall so that the maximum number of darts that Alice throws lie on the dartboard. Given the integer r, return the maximum number of darts that can lie on the dartboard.

Solution:

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

class Solution { public:
    int numPoints(vector<vector<int>>& darts, int r) {
        int maxCount = 1, n = darts.size();         for (int i = 0; i < n; ++i) {
for (int j = i + 1; j < n; ++j) {                  double dx = darts[j][0] - darts[i][0], dy =
darts[j][1] - darts[i][1];                double dist = sqrt(dx * dx + dy * dy);
                if (dist > 2 * r) continue;                double midX = (darts[i][0] + darts[j][0])
/ 2.0, midY = (darts[i][1] + darts[j][1]) / 2.0;                double angle = sqrt(r * r - (dist
/ 2) * (dist / 2)), norm = dist ? r / dist :
0;
                maxCount = max(maxCount, count(darts, midX - norm * dy, midY + norm *
dx, r));
            }
        }
        return maxCount;
    }

private:
    int count(const vector<vector<int>>& darts, double cx, double cy, int r) {         int c
= 0;
        for (auto& dart : darts)             if (pow(dart[0] - cx, 2) + pow(dart[1] - cy, 2)
<= r * r + 1e-7) ++c;         return c;
    }
};

int main() {     Solution sol;
    vector<vector<int>> darts = {{-2, 0}, {2, 0}, {0, 2}, {0, -2}};
cout << sol.numPoints(darts, 2) << endl; // Output: 4 }
```

```
4
5
```

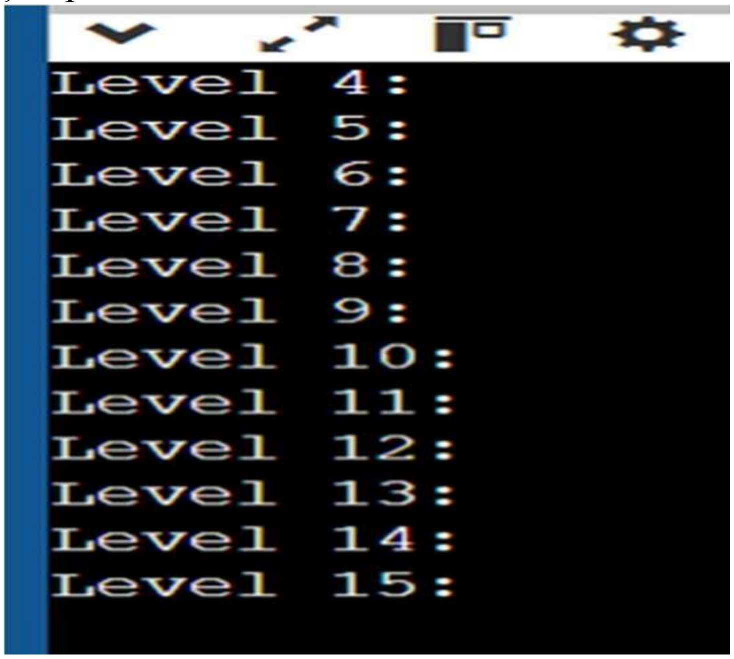
Problem 13: Design Skiplist

Design a Skiplist without using any built-in libraries. A skiplist is a data structure that takes O(log(n)) time to add, erase and search. Comparing with treap and redblack tree which has the same function and performance, the code length of Skiplist can be comparatively short and the idea behind Skiplists is just simple linked lists.

Solution:

```
#include <iostream>
#include <cstdlib>
#include <ctime>
#include <vector>

using namespace std;

// Node structure for Skiplist struct Node {     int value;
vector<Node*> forward;  // Pointers to next nodes at each level

   Node(int value, int level) : value(value), forward(level, nullptr) {} };

// Skiplist class class
Skiplist { private:
   int maxLevel;          // Maximum level for the skiplist     float probability;      //
Probability of promoting a node to a higher level     Node* header;          // Header
node

   // Random level generator function     int
randomLevel() {        int level = 1;
      while ((rand() % 2) < probability && level < maxLevel) {
         level++;
      }
      return level;
   }

public:
   Skiplist(int maxLevel = 16, float probability = 0.5)          :
maxLevel(maxLevel), probability(probability) {
      header = new Node(-1, maxLevel);  // Header node with a dummy value
   }

   // Search for a value in the Skiplist
bool search(int target) {        Node*
current = header;
      for (int i = maxLevel - 1; i >= 0; --i) {            while (current->forward[i] !=
nullptr && current->forward[i]->value < target) {               current = current-
>forward[i];
```

```
            }
        }
        current = current->forward[0];        return (current != nullptr
&& current->value == target);
    }

    // Insert a value into the Skiplist       void insert(int
value)  {                 vector<Node*>  update(maxLevel,
nullptr);
        Node* current = header;

        for (int i = maxLevel - 1; i >= 0; --i) {             while (current->forward[i] !=
nullptr && current->forward[i]->value < value) {                 current = current-
>forward[i];
            }
            update[i] = current;
        }

        current = current->forward[0];        if (current ==
nullptr || current->value != value) {            int level =
randomLevel();
            Node* newNode = new Node(value, level);

            for (int i = 0; i < level; ++i) {                newNode-
>forward[i] = update[i]->forward[i];                update[i]-
>forward[i] = newNode;
            }
        }
    }

    // Erase a value from the Skiplist       void erase(int
value)  {                 vector<Node*>  update(maxLevel,
nullptr);
        Node* current = header;

        for (int i = maxLevel - 1; i >= 0; --i) {             while (current->forward[i] !=
nullptr && current->forward[i]->value < value) {                 current = current-
>forward[i];
            }
            update[i] = current;
        }

        current = current->forward[0];          if (current != nullptr
&& current->value == value) {              for (int i = 0; i <
maxLevel; ++i) {                 if (update[i]->forward[i] !=
current) break;                 update[i]->forward[i] = current-
>forward[i];
            }
            delete current;
        }
    }

    // Print the Skiplist     void
print() {
        for (int i = 0; i < maxLevel; ++i) {
Node* current = header->forward[i];              cout
<< "Level " << i << ": ";              while (current !=
nullptr) {                  cout << current->value << " ";
                current = current->forward[i];
            }
            cout << endl;
        }
    }
};

int main() {     srand(time(0));  // Seed for random level
generation

    Skiplist skiplist;

    // Insert values into the Skiplist
skiplist.insert(30);     skiplist.insert(40);
skiplist.insert(50);     skiplist.insert(60);
skiplist.insert(70);     skiplist.insert(90);

    // Print the Skiplist
    cout << "Skiplist after insertions:" << endl;     skiplist.print();
    // Insert additional values
skiplist.insert(80);     skiplist.insert(45);

    cout << "Skiplist after adding 80 and 45:" << endl;     skiplist.print();

    // Search for some values
    cout << "Searching for 45: " << (skiplist.search(45) ? "Found" : "Not Found")
<< endl;
    cout << "Searching for 100: " << (skiplist.search(100) ? "Found" : "Not
Found") << endl;

    // Erase a value     skiplist.erase(50);     cout <<
"Skiplist after removing 50:" << endl;
skiplist.print();

    return 0;
}Ouput:
```



```
Level 4:
Level 5:
Level 6:
Level 7:
Level 8:
Level 9:
Level 10:
Level 11:
Level 12:
Level 13:
Level 14:
Level 15:
```

Problem 14: All O`one Data Structure

Design a data structure to store the strings' count with the ability to return the strings with minimum and maximum counts. Implement the AllOne class: ● AllOne() Initializes the object of the data structure. ● inc(String key) Increments the count of the string key by 1. If key does not exist in the data structure, insert it with count 1. ● dec(String key) Decrements the count of the string key by 1. If the count of key is 0 after the decrement, remove it from the data structure. It is guaranteed that key exists in the data structure before the decrement. ● getMaxKey() Returns one of the keys with the maximal count. If no element exists, return an empty string "". ● getMinKey() Returns one of the keys with the minimum count. If no element exists, return an empty string "".

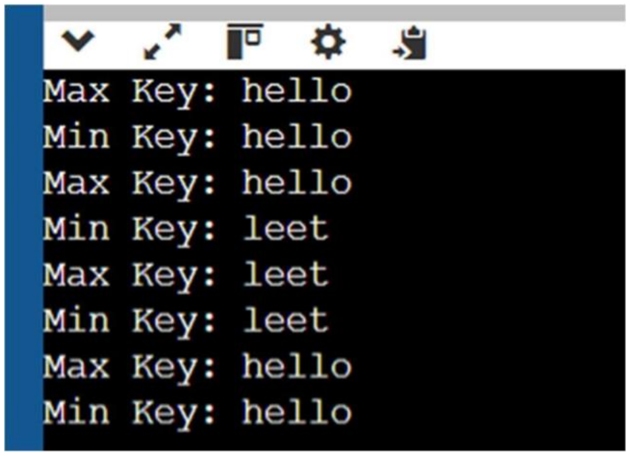
Solution:

```
#include <iostream>
#include <unordered_map>
#include <string>
#include <list> #include
<map> using namespace std;
class AllOne { private:
   // Hash map to store the count of each key      unordered_map<string,
int> keyCount;

   // Map to store the strings by their counts, ordered by counts
map<int, list<string>> countKeys; public:
   AllOne() {}
   // Increment the count of a string by 1
void inc(string key) {         int count =
keyCount[key];
      // Remove the key from its old count list
      if (count > 0) {
         countKeys[count].remove(key);
if (countKeys[count].empty()) {
countKeys.erase(count);}}
      // Increment the count and add the key to the new count list
keyCount[key] = count + 1;         countKeys[count +
1].push_back(key);}      // Decrement the count of a string by 1      void
dec(string key) {         int count = keyCount[key];
```

```
        // Remove the key from its current count list
countKeys[count].remove(key);         if
(countKeys[count].empty()) {
countKeys.erase(count); }
        // If count becomes 0, remove the key from keyCount
if (count == 1) {             keyCount.erase(key);
        } else {
            keyCount[key] = count - 1;
            countKeys[count - 1].push_back(key);}}     //
Get the key with the maximum count     string
getMaxKey() {
        if (countKeys.empty()) return "";         // Get
the last element (maximum count)
        return countKeys.rbegin()->second.front();
    }

    // Get the key with the minimum count     string
getMinKey() {
        if (countKeys.empty()) return "";         // Get
the first element (minimum count)
        return countKeys.begin()->second.front();
    }
};

int main() {
    AllOne allOne;

    allOne.inc("hello");     allOne.inc("hello");     cout << "Max Key: " <<
allOne.getMaxKey() << endl; // "hello"     cout << "Min Key: " <<
allOne.getMinKey() << endl; // "hello"

    allOne.inc("leet");
    cout << "Max Key: " << allOne.getMaxKey() << endl; // "hello"     cout <<
"Min Key: " << allOne.getMinKey() << endl; // "leet"

    allOne.dec("hello");     cout << "Max Key: " << allOne.getMaxKey()
<< endl; // "hello"     cout << "Min Key: " << allOne.getMinKey() <<
endl; // "leet"
```

```
    allOne.dec("leet");     cout << "Max Key: " << allOne.getMaxKey() <<
endl; // "hello"     cout << "Min Key: " << allOne.getMinKey() << endl;
// "hello"

    return 0;
}
```

Output:



```
Max Key: hello
Min Key: hello
Max Key: hello
Min Key: leet
Max Key: leet
Min Key: leet
Max Key: hello
Min Key: hello
```

Problem 15: Find Minimum Time to Finish All Jobs

You are given an integer array jobs, where jobs[i] is the amount of time it takes to complete the ith job.There are k workers that you can assign jobs to. Each job should be assigned to exactly one worker. The working time of a worker is the sum of the time it takes to complete all jobs assigned to them. Your goal is to devise an optimal assignment such that the maximum working time of any worker is minimized. Return the minimum possible maximum working time of any assignment.

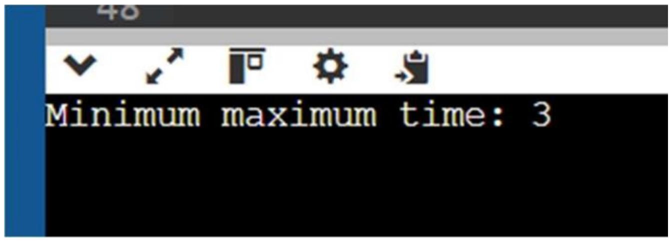
Solution:

```
#include <iostream>
#include <vector>
#include <numeric>
#include <algorithm>
```

```
using namespace std;

// Helper function to check if we can distribute jobs with max workload <= mid bool
canAssignJobs(const vector<int>& jobs, int k, int mid) {     int currentSum = 0;     int
workersUsed = 1; // Start with one worker

    for (int job : jobs) {
        if (currentSum + job > mid) {
            // Need a new worker since current worker cannot take this job
workersUsed++;             currentSum = job;             if (workersUsed > k)
return false; // More workers than allowed
        } else {
            currentSum += job;
        }     }
    return true;
}

int minimumTimeRequired(vector<int>& jobs, int k) {     int left =
*max_element(jobs.begin(), jobs.end()); // Max job time     int right =
accumulate(jobs.begin(), jobs.end(), 0); // Sum of all jobs

    while (left < right) {
        int mid = left + (right - left) / 2;
        if (canAssignJobs(jobs, k, mid)) {             right = mid;
// Try for a smaller max workload
        } else {
            left = mid + 1; // Increase the allowed max workload
        }
    }

    return left;
}

int main() {     vector<int> jobs = {3,
2, 3};     int k = 3;
    cout << "Minimum maximum time: " << minimumTimeRequired(jobs, k) << endl;
return 0;
```

}

Output:



```
Minimum maximum time: 3
```

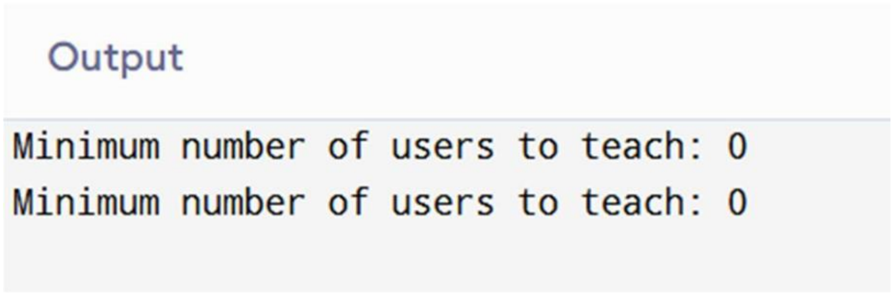
Problem 16: Minimum Number of People to Teach:
On a social network consisting of m users and some friendships between users, two users can communicate with each other if they know a common language. You are given an integer n, an array languages, and an array friendships where: There are n languages numbered 1 through n, languages[i] is the set of languages the ith user knows, and friendships[i] = [ui, vi] denotes a friendship between the users ui and vi. You can choose one language and teach it to some users so that all friends can communicate with each other. Return the minimum number of users you need to teach. Note that friendships are not transitive, meaning if x is a friend of y and y is a friend of z, this doesn't guarantee that x is a friend of z.

Solution:

```
#include <iostream>
#include <vector>
#include <unordered_set>
#include <unordered_map>

using namespace std;

class UnionFind { public:
    UnionFind(int n) {        parent.resize(n);
size.resize(n, 1);        for (int i = 0; i < n; ++i)
parent[i] = i;
    }

    int find(int u) {        if (parent[u] != u) {            parent[u]
= find(parent[u]); // Path compression
        }
        return parent[u];
    }

    void unionSets(int u, int v) {        int rootU = find(u);        int
rootV = find(v);        if (rootU != rootV) {            if
(size[rootU] < size[rootV]) swap(rootU, rootV);
parent[rootV] = rootU;
            size[rootU] += size[rootV];
        }
    }

private:
    vector<int> parent;     vector<int>
size;
};

int minimumTeachings(int n, vector<vector<int>>& languages,
vector<vector<int>>& friendships) {     int m = languages.size(); //
Number of users

    // Step 1: Union-Find initialization for users
    UnionFind uf(m);

    // Step 2: Union users who share a common language
    unordered_map<int, vector<int>> languageUsers;
    for (int i = 0; i < m; ++i) {        for (int lang :
languages[i]) {
languageUsers[lang].push_back(i);
        }
    }
    // Union users based on shared languages      for
(auto& [lang, users] : languageUsers) {          for (int
i = 0; i < users.size(); ++i) {              for (int j = i + 1;
j < users.size(); ++j) {
                uf.unionSets(users[i], users[j]);
            }
        }
    }

    // Step 3: Union users based on friendships      for
(auto& friendship : friendships) {
        int u = friendship[0] - 1;         int v
= friendship[1] - 1;         if (uf.find(u)
!= uf.find(v)) {
            uf.unionSets(u, v);
        }
    }

    // Step 4: Find the connected components and check if they can communicate
unordered_map<int, unordered_set<int>> components;      for (int i = 0; i < m; ++i) {
int root = uf.find(i);          for (int lang : languages[i]) {
            components[root].insert(lang);
        }
    }

    // Step 5: Determine how many users need to be taught a new language      int
result = 0;
    for (auto& [component, langs] : components) {
        // If no language is shared among users in this component, we need to teach at
least one user          if (langs.empty()) {             result++;
        }
    }

    return result;
}
```

```
int main() {     vector<vector<int>> languages1 = {{1}, {2}, {1, 2}};
vector<vector<int>> friendships1 = {{1, 2}, {1, 3}, {2, 3}};     int n1
= 2;
    cout << "Minimum number of users to teach: " << minimumTeachings(n1,
languages1, friendships1) << endl;

    vector<vector<int>> languages2 = {{2}, {1, 3}, {1, 2}, {3}};
vector<vector<int>> friendships2 = {{1, 4}, {1, 2}, {3, 4}, {2, 3}};     int n2 =
3;
    cout << "Minimum number of users to teach: " << minimumTeachings(n2,
languages2, friendships2) << endl;

    return 0;
}
```

Output:



Output

```
Minimum number of users to teach: 0
Minimum number of users to teach: 0
```

Problem 17: Count Ways to Make Array With Product

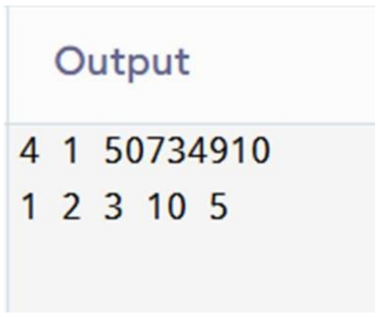
You are given a 2D integer array, queries. For each queries[i], where queries[i] = [ni, ki], find the number of different ways you can place positive integers into an array of size ni such that the product of the integers is ki. As the number of ways may be too large, the answer to the ith query is the number of ways modulo 109 + 7. Return an integer array answer where answer.length == queries.length, and answer[i] is the answer to the ith query.

Solution:

```
#include <iostream>
#include <vector>
#include <cmath>

const int MOD = 1e9 + 7;
const int MAXN = 10000;

// Precompute factorials and modular inverses using Fermat's Little Theorem
std::vector<long long> factorial(MAXN + 1), inv_factorial(MAXN + 1);

// Function to compute x^y % MOD
long long mod_exp(long long x, long long y, long long mod) {
long long result = 1;     while (y > 0) {         if (y % 2 == 1) result =
(result * x) % mod;         x = (x * x) % mod;
        y /= 2;
    }
    return result;
}

// Function to precompute factorials and their inverses void
precompute() {
    factorial[0] = inv_factorial[0] = 1;     for (int
i = 1; i <= MAXN; ++i) {
        factorial[i] = (factorial[i - 1] * i) % MOD;
    }
    inv_factorial[MAXN] = mod_exp(factorial[MAXN], MOD - 2, MOD); // Using
Fermat's little theorem     for (int i = MAXN - 1; i >= 1; --i) {         inv_factorial[i]
= (inv_factorial[i + 1] * (i + 1)) % MOD;
    }
}

// Function to compute binomial coefficient C(n, k) % MOD
long long binomial(int n, int k) {     if (k > n || k < 0) return 0;     return (factorial[n] *
inv_factorial[k] % MOD) * inv_factorial[n - k] % MOD; }
```

```
// Function to get the prime factorization of a number
std::vector<std::pair<int, int>> prime_factors(int k) {
std::vector<std::pair<int, int>> factors;     for (int i = 2; i * i
<= k; ++i) {         if (k % i == 0) {            int count = 0;
while (k % i == 0) {                 k /= i;                 count++;
            }
            factors.push_back({i, count});
        }            }            if  (k  >  1)  {
factors.push_back({k, 1});
    }
    return factors;
}

// Function to solve each query long
long solve(int n, int k) {     // Prime
factorize k
    auto factors = prime_factors(k);

    long long result = 1;     for (const auto&
factor : factors) {         int prime =
factor.first;         int exponent =
factor.second;
        // Calculate number of ways to split exponent of this prime into n parts         result
= (result * binomial(exponent + n - 1, n - 1)) % MOD;
    }

    return result;
}

std::vector<int> waysToPlaceIntegers(std::vector<std::vector<int>>& queries) {
precompute(); // Precompute factorials and inverses     std::vector<int> result;

    for (auto& query : queries) {
        int n = query[0];         int k =
query[1];         result.push_back(solve(n,
k));
    }

    return result;
}

int main() {     // Example
usage
    std::vector<std::vector<int>> queries1 = {{2, 6}, {5, 1}, {73, 660}};
std::vector<int> result1 = waysToPlaceIntegers(queries1);

    for (int r : result1) {         std::cout
<< r << " ";
    }
    std::cout << std::endl;

    std::vector<std::vector<int>> queries2 = {{1, 1}, {2, 2}, {3, 3}, {4, 4}, {5,
5}};
    std::vector<int> result2 = waysToPlaceIntegers(queries2);

    for (int r : result2) {         std::cout
<< r << " ";
    }
    std::cout << std::endl;

    return 0;
}
```

Output:


Output

```
4 1 50734910
1 2 3 10 5
```

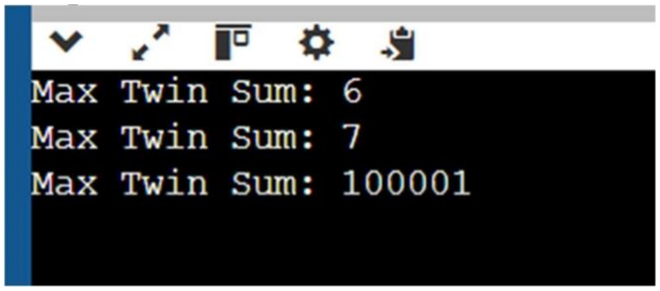
Problem 18: Maximum Twin Sum of a Linked List

In a linked list of size n, where n is even, the ith node (0-indexed) of the linked list is known as the twin of the (n-1-i)th node, if 0 <= i <= (n / 2) - 1. ● For example, if n = 4, then node 0 is the twin of node 3, and node 1 is the twin of node 2. These are the only nodes with twins for n = 4. The twin sum is defined as the sum of a node and its twin. Given the head of a linked list with even length, return the maximum twin sum of the linked list.

Code:

```
#include <iostream>
#include <vector>
#include <algorithm>

using namespace std;

// Definition for singly-linked list.
struct ListNode {     int val;
    ListNode* next;
    ListNode(int x) : val(x), next(nullptr) {}
};

class Solution { public:
    int pairSum(ListNode* head) {
        // Step 1: Store the values of the linked list in a vector         vector<int>
values;
        ListNode* current = head;

        // Traverse the linked list and add each node's value to the vector
while (current != nullptr) {             values.push_back(current->val);
            current = current->next;
        }

        // Step 2: Calculate the maximum twin sum
        int n = values.size();
        int maxTwinSum = 0;

        // Iterate over the first half of the list and calculate twin sums
for (int i = 0; i < n / 2; ++i) {             int twinSum = values[i] + values[n
- 1 - i];
            maxTwinSum = max(maxTwinSum, twinSum);
        }
        return maxTwinSum;
    }
};

// Helper function to create a linked list from a vector
ListNode* createList(const vector<int>& nums) {
    ListNode* head = new ListNode(nums[0]);
    ListNode* current = head;     for (int i = 1; i <
nums.size(); ++i) {         current->next = new
ListNode(nums[i]);
        current = current->next;
    }
    return head;
}

int main() {     // Example 1     vector<int>
input1 = {5, 4, 2, 1};
    ListNode* head1 = createList(input1);
    Solution sol;
    cout << "Max Twin Sum: " << sol.pairSum(head1) << endl;  // Output: 6

    // Example 2
    vector<int> input2 = {4, 2, 2, 3};     ListNode*
head2 = createList(input2);
    cout << "Max Twin Sum: " << sol.pairSum(head2) << endl;  // Output: 7

    // Example 3
    vector<int> input3 = {1, 100000};
    ListNode* head3 = createList(input3);     cout << "Max Twin Sum: " <<
sol.pairSum(head3) << endl;  // Output:
100001

    return 0;
}
```

Output:



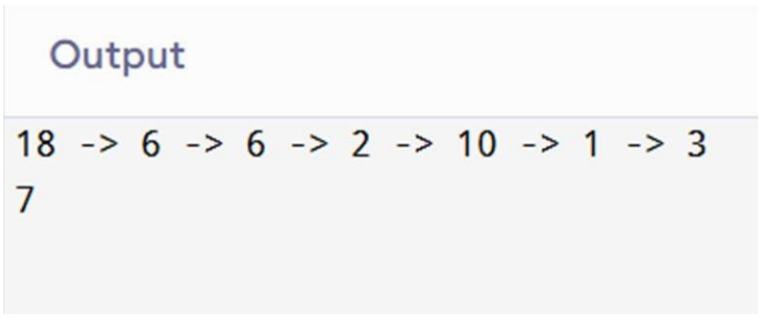
```
Max Twin Sum: 6
Max Twin Sum: 7
Max Twin Sum: 100001
```

Problem 19: Insert Greatest Common Divisors in Linked List
Given the head of a linked list head, in which each node contains an integer value. Between every pair of adjacent nodes, insert a new node with a value equal to the greatest common divisor of them. Return the linked list after insertion. The greatest common divisor of two numbers is the largest positive integer that evenly divides both numbers. Solution:

```
#include <iostream>
#include <vector>  // Include the vector header
#include <algorithm>
using namespace std;

// Definition for singly-linked list.
struct ListNode {
   int val;
   ListNode* next;
   ListNode(int x) : val(x), next(nullptr) {}
};

class Solution { public:
   // Function to compute GCD of two numbers     int
gcd(int a, int b) {        while (b != 0) {
           int temp = b;
b = a % b;            a =
temp;
       }        return a;
   }

   // Function to insert GCD nodes between each pair of adjacent nodes
   ListNode* insertGreatestCommonDivisors(ListNode* head) {
        // Edge case: If the list is empty or has only one node, no insertion is needed        if
(!head || !head->next) return head;

        ListNode* current = head;

        // Traverse the list
        while (current && current->next) {            int gcdValue = gcd(current->val,
current->next->val); // Calculate the
GCD
            ListNode* newNode = new ListNode(gcdValue); // Create a new node with
the GCD value             newNode->next = current->next; // Link the new node to the
next node             current->next = newNode; // Link the current node to the new node
current = newNode->next; // Move to the next pair of nodes
        }

        return head;
    }
};

// Helper function to create a linked list from a vector
ListNode* createList(const vector<int>& values) {     if
(values.empty()) return nullptr;
    ListNode* head = new ListNode(values[0]);
    ListNode* current = head;     for (int i = 1; i <
values.size(); ++i) {        current->next = new
ListNode(values[i]);
        current = current->next;
    }
    return head;
}

// Helper function to print the linked list
void printList(ListNode* head) {
    while (head) {        cout << head->val;
if (head->next) cout << " -> ";        head
= head->next;
    }
    cout << endl;
```

```
}

int main() {
    Solution sol;

    // Test case 1      vector<int> values1 = {18,
6, 10, 3};
    ListNode* head1 = createList(values1);
    ListNode* result1 = sol.insertGreatestCommonDivisors(head1);     printList(result1);
// Expected: 18 -> 6 -> 6 -> 2 -> 10 -> 1 -> 3

    // Test case 2
    vector<int> values2 = {7};
    ListNode* head2 = createList(values2);
    ListNode* result2 = sol.insertGreatestCommonDivisors(head2);     printList(result2);
// Expected: 7

    return 0;
}
```

Output:



Output

```
18 -> 6 -> 6 -> 2 -> 10 -> 1 -> 3
7
```