

# Leetcode Solutions

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## Introduction

Following are my solutions for some leetcode problems. The solutions and code are primarily in C++ owing to the fact that I'm already using Python in my research, and C++ for the engineering part. However, C++ is something I'm trying to go deeper owing to the fact that I'm improving my ability to build low latency systems, which primarily use C/C++.



# Template Script

## Description

The following script is forked each time I want to locally work on a leetcode problem. The subsequent solutions in the later sections also have the functions present in this particular script in their scope. So this script also serves to provide an idea as to the functions, and what not, that are available. Note that the standard practice is to have these functions written in another file and have it included in the main script. However, I often tinker with these functions based on the problem at hand. Thus, the not-so-standard approach.

## Template.cpp

---

```
1 // including header-files
2 #include <algorithm>
3 #include <unordered_set>
4 #include <bitset>
5 #include <climits>
6 #include <cstdint>
7 #include <iostream>
8 #include <limits>
9 #include <map>
10 #include <new>
11 #include <stdlib.h>
12 #include <unordered_map>
13 #include <vector>
14 #include <set>
15 #include <numeric>
16 #include <functional>
17
18
19 // hash-deinfes
20 #define PRINTSPACE std::cout << "\n\n\n" << std::endl;
```

```

21 #define PRINTLINE std::cout << "===== " << std::endl;
22
23 // borrowing from namespace std
24 using std::cout;
25 using std::endl;
26 using std::vector;
27 using std::string;
28 using std::unordered_map;
29 using std::map;
30 using std::format;
31 using std::deque;
32 using std::pair;
33 using std::min;
34 using std::max;
35
36 // vector printing function
37 template<typename T>
38 void fPrintVector(vector<T> input){
39     for(auto x: input) cout << x << ", ";
40     cout << endl;
41 }
42
43 template<typename T>
44 void fpv(vector<T> input){
45     for(auto x: input) cout << x << ", ";
46     cout << endl;
47 }
48
49 template<typename T>
50 void fPrintMatrix(vector<T> input){
51     for(auto x: input){
52         for(auto y: x){
53             cout << y << ", ";
54         }
55         cout << endl;

```

```

56     }
57 }
58
59 template<typename T, typename T1>
60 void fPrintHashmap(unordered_map<T, T1> input){
61     for(auto x: input){
62         cout << format("[{},{}] | ", x.first, x.second);
63     }
64     cout << endl;
65 }
66
67 struct TreeNode {
68     int val;
69     TreeNode *left;
70     TreeNode *right;
71     TreeNode() : val(0), left(nullptr), right(nullptr) {}
72     TreeNode(int x) : val(x), left(nullptr), right(nullptr) {}
73     TreeNode(int x, TreeNode *left, TreeNode *right) : val(x), left(left), right(right) {}
74 };
75
76
77 struct ListNode {
78     int val;
79     ListNode *next;
80     ListNode() : val(0), next(nullptr) {}
81     ListNode(int x) : val(x), next(nullptr) {}
82     ListNode(int x, ListNode *next) : val(x), next(next) {}
83 };
84
85 void fPrintBinaryTree(TreeNode* root){
86     // sending it back
87     if (root == nullptr) return;
88
89     // printing
90     PRINTLINE

```

```

91     cout << "root->val = " << root->val << endl;
92
93     // calling the children
94     fPrintBinaryTree(root->left);
95     fPrintBinaryTree(root->right);
96
97     // returning
98     return;
99
100 }
101
102 void fPrintLinkedList(string prefix,
103                      ListNode* root){
104     if (root == nullptr) return;
105     cout << prefix;
106     std::function<void(ListNode*)> runlinkedlist = [&runlinkedlist](ListNode* root){
107         if (root == nullptr) return;
108         cout << root->val << " -> ";
109         runlinkedlist(root->next);
110     };
111     runlinkedlist(root);
112     cout << "|" << endl;
113     return;
114 }
115
116 template<typename T>
117 void fPrintContainer(T input){
118     for(auto x: input) cout << x << ", ";
119     cout << endl;
120     return;
121 }
122
123 struct Timer
124 {
125     std::chrono::time_point<std::chrono::high_resolution_clock> startpoint;

```

```

126 std::chrono::time_point<std::chrono::high_resolution_clock> endpoint;
127 std::chrono::duration<long long, std::nano> duration;
128
129 // constructor
130 Timer() {startpoint = std::chrono::high_resolution_clock::now();}
131 void start() {startpoint = std::chrono::high_resolution_clock::now();}
132 void stop() {endpoint = std::chrono::high_resolution_clock::now(); fetchtime();}
133
134 void fetchtime(){
135     duration = std::chrono::duration_cast<std::chrono::nanoseconds>(endpoint - startpoint);
136     cout << format("{} nanoseconds \n", duration.count());
137 }
138 void fetchtime(string stringarg){
139     duration = std::chrono::duration_cast<std::chrono::nanoseconds>(endpoint - startpoint);
140     cout << format("{} took {} nanoseconds \n", stringarg, duration.count());
141 }
142 void measure(){
143     auto temp = std::chrono::high_resolution_clock::now();
144     auto nsduration = std::chrono::duration_cast<std::chrono::nanoseconds>(temp - startpoint);
145     auto msduration = std::chrono::duration_cast<std::chrono::microseconds>(temp - startpoint);
146     auto sduration = std::chrono::duration_cast<std::chrono::seconds>(temp - startpoint);
147     cout << format("{} nanoseconds | {} microseconds | {} seconds \n",
148         nsduration.count(), msduration.count(), sduration.count());
149 }
150 ~Timer(){
151     measure();
152 }
153 };
154
155 // main-file =====
156 int main(){
157
158     // starting timer
159     Timer timer;
160

```

```
161 // input- configuration
162
163
164 // setup
165
166
167
168
169
170 // return
171 return(0);
172
173 }
```

---

## 1. Two Sum

Given an array of integers `nums` and an integer `target`, return indices of the two numbers such that they add up to `target`. You may assume that each input would have exactly one solution, and you may not use the same element twice. You can return the answer in any order.

### Examples

#### 1. Example 1:

- Input: `nums = [2,7,11,15]`, `target = 9`
- Output: `[0,1]`
- Explanation: Because `nums[0] + nums[1] == 9`, we return `[0, 1]`.

#### 2. Example 2:

- Input: `nums = [3,2,4]`, `target = 6`
- Output: `[1,2]`

#### 3. Example 3:

- Input: `nums = [3,3]`, `target = 6`
- Output: `[0,1]`

### Constraints:

- $2 \leq \text{nums.length} \leq 10^4$

- $-10^9 \leq \text{nums}[i] \leq 10^9$
- $-10^9 \leq \text{target} \leq 10^9$
- Only one valid answer exists.

## Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> nums {2, 7, 11, 15};
5     int target {9};
6
7     // setup
8     int complement {0};
9     unordered_map<int, int> number_to_index;
10    vector<int> finaloutput;
11
12    // filling the unordered_map
13    for(int i = 0; i < nums.size(); ++i){
14
15        // calculating complement
16        complement = target - nums[i];
17
18        // checking if complement is present in registry
19        if(number_to_index.find(complement) != number_to_index.end()) [[unlikely]]
20        {
21            finaloutput.push_back(number_to_index[complement]); // adding first index
22            finaloutput.push_back(i); // adding second index
23            break; // breaking out
24        }
25        else [[likely]]
```



```

26 {
27     // check if current element is present
28     if (number_to_index.find(nums[i]) == number_to_index.end()) [[likely]]
29     {
30         // adding the [number, index] pair to the hashmap
31         number_to_index[nums[i]] = i;
32     }
33     else [[unlikely]]
34     {
35         // we'll do nothing since the number and its index is already present
36         continue;
37     }
38 }
39 }
40
41 // printing the final output
42 for(const auto& x : finaloutput) {cout << x << ", ";} cout << endl;
43
44 // return
45 return(0);
46
47 }

```

---

## 2. Add Two Numbers

You are given two non-empty linked lists representing two non-negative integers. The digits are stored in reverse order, and each of their nodes contains a single digit. Add the two numbers and return the sum as a linked list. You may assume the two numbers do not contain any leading zero, except the number 0 itself.

### Examples

#### 1. Example 1:

- Input:  $l1 = [2,4,3]$ ,  $l2 = [5,6,4]$
- Output:  $[7,0,8]$
- Explanation:  $342 + 465 = 807$ .

#### 2. Example 2:

- Input:  $l1 = [0]$ ,  $l2 = [0]$
- Output:  $[0]$

#### 3. Example 3:

- Input:  $l1 = [9,9,9,9,9,9,9]$ ,  $l2 = [9,9,9,9]$
- Output:  $[8,9,9,9,0,0,0,1]$

### Constraints:

- The number of nodes in each linked list is in the range  $[1, 100]$ .

- $0 \leq \text{Node.val} \leq 9$
- It is guaranteed that the list represents a number that does not have leading zeros.

## Code

---

```
1 int main(){
2
3     // input- configuration
4     ListNode* l1 = new ListNode(2);
5     l1->next = new ListNode(4);
6     l1->next->next = new ListNode(3);
7
8     ListNode* l2 = new ListNode(5);
9     l2->next = new ListNode(6);
10    l2->next->next = new ListNode(4);
11
12    // setup
13    ListNode* traveller_1 = l1;
14    ListNode* traveller_2 = l2;
15    ListNode* finalOutput = new ListNode(-1);
16    ListNode* traveller_fo = finalOutput;
17
18    int sum          {0};
19    int carry        {0};
20    int value_1      {0};
21    int value_2      {0};
22
23    // moving through the two nodes
24    while(traveller_1 != nullptr || traveller_2 != nullptr){
25
26        // adding the two numbers
27        value_1 = traveller_1 == nullptr ? 0 : traveller_1->val;
```

```

28     value_2 = traveller_2 == nullptr ? 0 : traveller_2->val;
29
30     // calculating sum
31     sum      = value_1 + value_2 + carry;
32     if (sum >= 10) [[unlikely]] {sum -= 10; carry = 1;}
33     else      [[likely]]      {carry = 0;}
34
35     // creating node
36     traveller_fo->next = new ListNode(sum);
37     traveller_fo      = traveller_fo->next;
38
39     // updating the two pointers
40     if(traveller_1 != nullptr) [[likely]] {traveller_1 = traveller_1->next;}
41     if(traveller_2 != nullptr) [[likely]] {traveller_2 = traveller_2->next;}
42 }
43
44 // creating a final node if carry is non-zero
45 if (carry == 1) [[unlikely]] {
46     traveller_fo->next = new ListNode(carry);
47 }
48
49 // printing the final output
50 traveller_fo = finalOutput->next;
51 cout << format("final-output = ");
52 while(traveller_fo != nullptr){
53     cout << traveller_fo->val << ", ";
54     traveller_fo = traveller_fo->next;
55 }
56 cout << "\n";
57
58 // return
59 return(0);
60
61 }

```

---

### 3. Longest Substring Without Repeating Characters

Given a string  $s$ , find the length of the longest substring without duplicate characters.

#### Examples

1. **Example 1:**

- Input:  $s = \text{"abcabcbb"}$
- Output: 3
- Explanation: The answer is "abc", with the length of 3.

2. **Example 2:**

- Input:  $s = \text{"bbbbbb"}$
- Output: 1
- Explanation: The answer is "b", with the length of 1.

3. **Example 3:**

- Input:  $s = \text{"pwwkew"}$
- Output: 3
- Explanation: The answer is "wke", with the length of 3.
  - Notice that the answer must be a substring, "pwke" is a subsequence and not a substring.

## Constraints

- $0 \leq \text{s.length} \leq 5 * 10^4$
- s consists of English letters, digits, symbols and spaces.

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto s      {string("abcabcbb")};
8
9     // trivial cases
10    if (s.size() <= 1) {cout << format("final-output = {}\n", s.size()); return 0;}
11
12    // setup
13    unordered_map<char, int> histogram;
14    char curr;
15    auto p1      {0};
16    auto finaloutput {-1};
17    auto temp_length {-1};
18
19    // going through the thing
20    for(int p2 = 0; p2<s.size(); ++p2){
21
22        // moving to another variable
23        curr = s[p2];
24
25        // checking if current character is in histogram
```

```

26     if (histogram.find(curr) == histogram.end()) [[unlikely]] {histogram[curr] = 1;}
27     else [[likely]]
28     {
29         // checking if count is zero
30         if (histogram[curr] == 0) {histogram[curr] = 1;}
31         else{
32             // moving p1 until it arrives at first instance of curr
33             while(s[p1] != curr) {--histogram[s[p1]]; ++p1;}
34             ++p1;
35             histogram[curr] = 1;
36         }
37     }
38
39     // calculating longest length
40     finaloutput = finaloutput > (p2-p1+1) ? finaloutput : (p2-p1+1);
41 }
42
43 // returning the final output
44 cout << format("final-output = {}\n", finaloutput);
45
46 // return
47 return(0);
48
49 }

```

---

## 4. Median Of Two Sorted Array

Given two sorted arrays `nums1` and `nums2` of size `m` and `n` respectively, return the median of the two sorted arrays. The overall run time complexity should be  $O(\log(m+n))$ .

### Examples

#### 1. Example 1:

- Input: `nums1 = [1,3]`, `nums2 = [2]`
- Output: 2.00000
- Explanation: merged array = `[1,2,3]` and median is 2.

#### 2. Example 2:

- Input: `nums1 = [1,2]`, `nums2 = [3,4]`
- Output: 2.50000
- Explanation: merged array = `[1,2,3,4]` and median is  $(2 + 3) / 2 = 2.5$ .

### Constraints:

1. `nums1.length == m`
2. `nums2.length == n`
3.  $0 \leq m \leq 1000$



4.  $0 \leq n \leq 1000$
5.  $1 \leq m + n \leq 2000$
6.  $-10^6 \leq \text{nums1}[i], \text{nums2}[i] \leq 10^6$

## Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> nums1 {1, 2};
5     vector<int> nums2 {3, 4};
6
7
8     // setup
9     vector<int>& first = nums1[0] <= nums2[0] ? nums1 : nums2;
10    vector<int>& second = nums1[0] > nums2[0] ? nums1 : nums2;
11    int left_first {0};
12    int right_first {static_cast<int>(first.size())-1};
13    int left_second {0};
14    int right_second {static_cast<int>(second.size())-1};
15    int left_value = first[left_first] < second[left_second] ? first[left_first] : second[left_second];
16    int right_value = first[right_first] > second[right_second] ? first[right_first] : second[right_second];
17    int numiterations {static_cast<int>((nums1.size() + nums2.size())/2)};
18
19
20    // running for a certain number of iterations
21    for(int i = 0; i<numiterations+1; ++i){
22
23        // updating left
24        if (first[left_first] < second[left_second]) {left_value = first[left_first]; ++left_first;}
25        else {left_value = second[left_second]; ++left_second;}
```

```
26     if (first[right_first] > second[right_second]) {right_value = first[right_first]; --right_first;}
27     else {right_value = second[right_second]; --right_second;}
28
29     // printing
30     cout << format("left-value = {}, right-value = {}\n", left_value, right_value);
31 }
32
33 cout << format("median = {}\n", static_cast<double>(left_value + right_value)/2.0);
34
35
36
37 // return
38 return(0);
39
40 }
```

---

## 5. Longest Palindromic Substring

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

### Examples

#### 1. Example 1:

- Input:  $s = \text{"babad"}$
- Output:  $\text{"bab"}$
- Explanation:  $\text{"aba"}$  is also a valid answer.

#### 2. Example 2:

- Input:  $s = \text{"cbbd"}$
- Output:  $\text{"bb"}$

### Constraints

- $1 \leq s.length \leq 1000$
- $s$  consist of only digits and English letters.

### Code

---

```

1  int main(){
2
3      // starting timer
4      Timer timer;
5
6      // input- configuration
7      auto s {string("babad")};
8
9
10     // setup
11     int maxlength {-1};
12     int boundary {1};
13     string largestpalindrome = "";
14
15     // going through the elements
16     for(int i = 0; i<s.size(); ++i){
17
18         // checking odd-palindromes from here
19         auto oddlength {1};
20         auto boundary {1};
21         string oddstring {s[i]};
22
23         while(i - boundary >= 0 && i + boundary < s.size() && s[i-boundary] == s[i+boundary]){
24             oddlength += 2;           // updating length
25             oddstring = s.substr(i-boundary, 2*boundary+1); // subsetting
26             ++boundary;              // updating boundary
27         }
28
29         // checking even-palindromes from here
30         auto evenlength {0};
31         boundary = 1;
32         auto evenstring {string("")};
33
34         while(i+1-boundary >= 0 && i+boundary < s.size() && s[i+1-boundary] == s[i+boundary]){

```

```

35     evenlength += 2;                                // updating length
36     evenstring = s.substr(i+1-boundary, 2*boundary); // subsetting
37     ++boundary;                                     // updating boundary
38 }
39
40 // updating largest-string
41 largestpalindrome = oddlength > largestpalindrome.size() ? oddstring : largestpalindrome;
42 largestpalindrome = evenlength > largestpalindrome.size() ? evenstring : largestpalindrome;
43
44 }
45
46 // returning
47 cout << format("final-output = {}\n", largestpalindrome);
48
49 // return
50 return(0);
51
52 }

```

---

## 6. Zigzag Conversion

The string "PAYPALISHIRING" is written in a zigzag pattern on a given number of rows like this: (you may want to display this pattern in a fixed font for better legibility)

P	-	A	-	H	-	N
A	P	L	S	I	I	G
Y	-	I	-	R	-	-

And then read line by line: "PAHNAPLSIIGYIR"

### Examples

#### 1. Example 1:

- Input: s = "PAYPALISHIRING", numRows = 3
- Output: "PAHNAPLSIIGYIR"

#### 2. Example 2:

- Input: s = "PAYPALISHIRING", numRows = 4
- Output: "PINALSIGYAHRPI"

#### 3. Example 3:

- Input: s = "A", numRows = 1
- Output: "A"

## Constraints:

1.  $1 \leq s.length \leq 1000$
2. s consists of English letters (lower-case and upper-case), ',' and '.'.
3.  $1 \leq numRows \leq 1000$

## Code

---

```
1 int main(){
2
3     // input- configuration
4     string s {"PAYPALISHIRING"};
5     int numRows {4};
6
7     // trivial case
8     if (numRows == 1) {cout << format("finaloutput = {}\n", s); return 0;}
9
10    // setup
11    int modlength {2*numRows-2};
12    int numblocks {(static_cast<int>(s.size()+ modlength-1)/modlength)};
13    int sourceindex {-1};
14    string finaloutput;
15
16    // going through the thing
17    for(int row = 0; row < numRows; ++row){
18        for(int i = 0; i<numblocks; ++i){
19
20            // first column of each block
21            sourceindex = row + modlength * i;
22            if (sourceindex<s.size()) {finaloutput += s[sourceindex];}
23
24        }
```

```

24     // continuing in case of boundary rows
25     if (row == 0 || row == numRows-1) {continue;}
26
27     // taking care of the case where non-boundary rows
28     sourceindex = modlength - row + modlength*i;
29     if (sourceindex < s.size())      {finaloutput += s[sourceindex];}
30 }
31 }
32
33 // printing the final output
34 cout << format("final-output = {}\n", finaloutput);
35
36
37 // return
38 return(0);
39
40 }

```

---



## 7. Reverse Integer

Given a signed 32-bit integer  $x$ , return  $x$  with its digits reversed. If reversing  $x$  causes the value to go outside the signed 32-bit integer range  $[-2^{31}, 2^{31} - 1]$ , then return 0.

Assume the environment does not allow you to store 64-bit integers (signed or unsigned).

### Examples

1. **Example 1:**

- Input:  $x = 123$
- Output: 321

2. **Example 2:**

- Input:  $x = -123$
- Output: -321

3. **Example 3:**

- Input:  $x = 120$
- Output: 21

### Constraints

- $-2^{31} \leq x \leq 2^{31} - 1$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto x {123};
8
9     // setup
10    auto finaloutput    {static_cast<long long>(0)};
11    auto leftboundary    {- std::pow(2, 31)};
12    auto rightboundary   {-1 + std::pow(2, 31)};
13
14    // building final output
15    while(x){
16
17        finaloutput = finaloutput*10 + x%10;
18        x           = x/10;
19        if (finaloutput < leftboundary || finaloutput > rightboundary) {return 0;} // checking the cases
20    }
21
22    // returning the final output
23    cout << format("final-output = {}\n", finaloutput);
24
25    // return
26    return(0);
27
28 }
```

---

## 9. Palindrome Number

Given an integer  $x$ , return true if  $x$  is a palindrome, and false otherwise.

### Examples

#### 1. Example 1:

- Input:  $x = 121$
- Output: true
- Explanation: 121 reads as 121 from left to right and from right to left.

#### 2. Example 2:

- Input:  $x = -121$
- Output: false
- Explanation: From left to right, it reads -121. From right to left, it becomes 121-. Therefore it is not a palindrome.

#### 3. Example 3:

- Input:  $x = 10$
- Output: false
- Explanation: Reads 01 from right to left. Therefore it is not a palindrome.

### Constraints

- $-2^{31} \leq x \leq -1$

## Code

---

```
1  int main(){
2
3      // starting timer
4      Timer timer;
5
6      // input- configuration
7      auto x {121};
8
9      // setup
10     auto finaloutput {false};
11
12     // retarded question
13     if (x<0) {cout << format("final-output = {}\n", finaloutput); return 0;}
14
15     // running
16     auto x_clone {x};
17     auto x_reverse {static_cast<long int>(0)};
18
19     // running through the value
20     while(x_clone){
21         x_reverse = x_reverse*10 + x_clone%10;
22         x_clone = x_clone/10;
23     }
24
25     // comparing the two
26     if (x == x_reverse) {finaloutput = true;}
27     else {finaloutput = false;}
28
29
30     // printing
31     cout << format("final-output = {}\n", finaloutput);
32
33 }
```

```
34     // return
35     return(0);
36
37 }
```

---

## 11. 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 `i`th 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. Notice that you may not slant the container.

### Examples

#### 1. Example 1:

- Input: `height = [1,8,6,2,5,4,8,3,7]`
- Output: 49
- Explanation: The above vertical lines are represented by array `[1,8,6,2,5,4,8,3,7]`. In this case, the max area of water (blue section) the container can contain is 49.

#### 2. Example 2:

- Input: `height = [1,1]`
- Output: 1

### Constraints

- `n == height.length`
- $2 \leq n \leq 10^5$
- $0 \leq \text{height}[i] \leq 10^4$

## Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> height {1,8,6,2,5,4,8,3,7};
5
6     // setup
7     int left      {0};
8     int right     {static_cast<int>(height.size()-1)};
9     int maxvolume {-1};
10    int currvolume {-1};
11
12    // two-pointer approach
13    while(left < right){
14
15        // calculating volumes
16        currvolume = (right - left) * std::min(height[left], height[right]);
17        maxvolume  = maxvolume > currvolume ? maxvolume : currvolume;
18
19        // adjusting left and right based on volume
20        if (height[left] < height[right]) {++left;}
21        else                               {--right;}
22    }
23
24    // printing
25    cout << format("maxvolume = {}\n", maxvolume);
26
27    // return
28    return(0);
29
30 }
```

---

## 12. Integer to Roman

Roman numerals are formed by appending the conversions of decimal place values from highest to lowest. Converting a decimal place value into a Roman numeral has the following rules:

- If the value does not start with 4 or 9, select the symbol of the maximal value that can be subtracted from the input, append that symbol to the result, subtract its value, and convert the remainder to a Roman numeral.
- If the value starts with 4 or 9 use the subtractive form representing one symbol subtracted from the following symbol, for example, 4 is 1 (I) less than 5 (V): IV and 9 is 1 (I) less than 10 (X): IX. Only the following subtractive forms are used: 4 (IV), 9 (IX), 40 (XL), 90 (XC), 400 (CD) and 900 (CM).
- Only powers of 10 (I, X, C, M) can be appended consecutively at most 3 times to represent multiples of 10. You cannot append 5 (V), 50 (L), or 500 (D) multiple times. If you need to append a symbol 4 times use the subtractive form.

Given an integer, convert it to a Roman numeral.

### Examples

#### 1. Example 1

- Input: num = 3749
- Output: "MMMDCCXLIX"
- Explanation:
  - 3000 = MMM as 1000 (M) + 1000 (M) + 1000 (M)
  - 700 = DCC as 500 (D) + 100 (C) + 100 (C)
  - 40 = XL as 10 (X) less of 50 (L)
  - 9 = IX as 1 (I) less of 10 (X)



- Note: 49 is not 1 (I) less of 50 (L) because the conversion is based on decimal places

## 2. Example 2:

- Input: num = 58
- Output: "LVIII"
- Explanation:
  - 50 = L
  - 8 = VIII

## 3. Example 3:

- Input: num = 1994
- Output: "MCMXCIV"
- Explanation:
  - 1000 = M
  - 900 = CM
  - 90 = XC
  - 4 = IV

## Constraints

- $1 \leq \text{num} \leq 3999$

## Code

---

```

1  int main(){
2
3      // input- configuration
4      int num    {1994};
5
6      // setup
7      vector<pair<int, string>> numToString {
8          {1, "I"},
9          {4, "IV"},
10         {5, "V"},
11         {9, "IX"},
12         {10, "X"},
13         {40, "XL"},
14         {50, "L"},
15         {90, "XC"},
16         {100, "C"},
17         {400, "CD"},
18         {500, "D"},
19         {900, "CM"},
20         {1000, "M"}
21     };
22     string finaloutput;
23     int    count;
24     auto mulstring = [](const int& count,
25                         const string& inputstring,
26                         string& finaloutput){
27         if (count == 0) {return;}
28         for(int i = 0; i<count; ++i){finaloutput += inputstring;}
29     };
30
31     // going through the hashmap from the end
32     for(int i = numToString.size()-1; i>=0; --i){
33
34         // number-string pairs
35         // variable to hold the final output
36         // variable that will hold the counts
37
38         // lambda-function for int * string

```

```
34     // calculating count
35     count  = num / numToString[i].first;
36     num    = num - numToString[i].first*count;
37
38     // adding to final output
39     mulstring(count, numToString[i].second, finaloutput);
40 }
41
42 // printing the final-output
43 cout << format("finaloutput = {}\n", finaloutput);
44
45 // return
46 return(0);
47
48 }
```

---

## 13. Roman To Integer

Roman numerals are represented by seven different symbols: I(1), V(5), X(10), L(50), C(100), D(500) and M(1000). For example, 2 is written as II in Roman numeral, just two ones added together. 12 is written as XII, which is simply X + II. The number 27 is written as XXVII, which is XX + V + II. Roman numerals are usually written largest to smallest from left to right. However, the numeral for four is not IIII. Instead, the number four is written as IV. Because the one is before the five we subtract it making four. The same principle applies to the number nine, which is written as IX. There are six instances where subtraction is used:

1. I can be placed before V (5) and X (10) to make 4 and 9.
2. X can be placed before L (50) and C (100) to make 40 and 90.
3. C can be placed before D (500) and M (1000) to make 400 and 900.

Given a roman numeral, convert it to an integer.

### Examples

#### 1. Example 1

- Input: s = "III"
- Output: 3
- Explanation: III = 3.

#### 2. Example 2

- Input: s = "LVIII"
- Output: 58

- Explanation: L = 50, V = 5, III = 3.

### 3. Example 3

- Input: s = "MCMXCIV"
- Output: 1994
- Explanation: M = 1000, CM = 900, XC = 90 and IV = 4.

## Constraints

1.  $1 \leq s.length \leq 15$
2. s contains only the characters ('I', 'V', 'X', 'L', 'C', 'D', 'M').
3. It is guaranteed that s is a valid roman numeral in the range [1, 3999].

## Code

---

```
1 int main(){
2
3     // input- configuration
4     string s {"MCMXCIV"};
5
6     // setup
7     int finaloutput {0};
8     unordered_map<char, int> charToInt {{'I', 1},
9                                           {'V', 5},
10                                          {'X', 10},
11                                          {'L', 50},
12                                          {'C', 100},
```

```
13         {'D', 500},
14         {'M', 1000}};
15
16 // going through the string
17 for(int i = 0; i<s.size(); ++i){
18     if ((i+1)<s.size() && charToInt[s[i]] < charToInt[s[i+1]]) {finaloutput -= charToInt[s[i]];}
19     else {finaloutput += charToInt[s[i]];}
20 }
21
22 // printing the final output
23 cout << format("finaloutput = {}\n", finaloutput);
24
25 // return
26 return(0);
27
28 }
```

---

## 14. Longest Common Prefix

Write a function to find the longest common prefix string amongst an array of strings. If there is no common prefix, return an empty string "".

### Examples

#### 1. Example 1:

- Input: `strs = ["flower", "flow", "flight"]`
- Output: `"fl"`

#### 2. Example 2:

- Input: `strs = ["dog", "racecar", "car"]`
- Output: `""`
- Explanation: There is no common prefix among the input strings.

### Constraints:

- $1 \leq \text{strs.length} \leq 200$
- $0 \leq \text{strs}[i].\text{length} \leq 200$
- `strs[i]` consists of only lowercase English letters if it is non-empty.

## Code

---

```
1  int main(){
2
3      // input- configuration
4      vector<string> strs {
5          "flower",
6          "flow",
7          "flight"
8      };
9
10     // setup
11     int p          {0};                // index-pointer for boundary
12     int runcondition {true};           // breaking condition
13     string prefix;
14
15     // going through the vector
16     while(runcondition){
17
18         // breaking if it doesn't meet first words length
19         if (p >= strs[0].size())      {++p; runcondition = false; break;}
20
21         // checking if this candidate
22         for(int i = 1; i<strs.size(); ++i){
23
24             // checking if valid
25             if (p >= strs[i].size())  {runcondition = false; break;}
26
27             // checking if same
28             if (strs[i][p] != strs[0][p]) {runcondition = false; break;}
29         }
30
31         // updating p
32         ++p;
33     }
```



```
34
35 // subsetting and printing the prefix
36 prefix = string(strs[0].begin(), strs[0].begin()+p-1);
37 cout << format("finaloutput = {}\n", prefix);
38
39 // return
40 return(0);
41
42 }
```

---

## 17. Letter Combinations of a Phone Number

Given a string containing digits from 2-9 inclusive, return all possible letter combinations that the number could represent. Return the answer in any order.

A mapping of digits to letters (just like on the telephone buttons) is given below. Note that 1 does not map to any letters.

### Examples

#### 1. Example 1:

- Input: digits = "23"
- Output: ["ad", "ae", "af", "bd", "be", "bf", "cd", "ce", "cf"]

#### 2. Example 2:

- Input: digits = ""
- Output: []

#### 3. Example 3:

- Input: digits = "2"
- Output: ["a", "b", "c"]

### Constraints

- $0 \leq \text{digits.length} \leq 4$
- `digits[i]` is a digit in the range ['2', '9'].

## Code

---

```
1 void foo(int           horizontalindex,
2         int           verticalindex,
3         string        digits,
4         string        runningstring,
5         vector<string>& finalOutput,
6         unordered_map<char, vector<string>>& charToLetter)
7 {
8
9     // adding current to running sum
10    runningstring += charToLetter[digits[verticalindex]][horizontalindex];
11
12    // sending it back
13    if (verticalindex == digits.size()-1) {finalOutput.push_back(runningstring); return;}
14
15    // running recursion on different sub-paths
16    for(int j = 0; j < charToLetter[digits[verticalindex+1]].size(); ++j)
17        foo(j, verticalindex+1,digits, runningstring, finalOutput, charToLetter);
18
19    // returning
20    return;
21 }
22
23 int main(){
24
25     // starting timer
26     Timer timer;
27
28     // input- configuration
29     auto digits {string("23")};
30
31     // trivial case
32     if (digits.size()==0) {
33         cout << format("final-output = {}\n", vector<string>({}));
```

```

34     return 0;
35 }
36
37 // setup
38 unordered_map<char, vector<string>> charToLetter;
39 charToLetter['2'] = vector<string>({"a", "b", "c"});
40 charToLetter['3'] = vector<string>({"d", "e", "f"});
41 charToLetter['4'] = vector<string>({"g", "h", "i"});
42 charToLetter['5'] = vector<string>({"j", "k", "l"});
43 charToLetter['6'] = vector<string>({"m", "n", "o"});
44 charToLetter['7'] = vector<string>({"p", "q", "r", "s"});
45 charToLetter['8'] = vector<string>({"t", "u", "v"});
46 charToLetter['9'] = vector<string>({"w", "x", "y", "z"});
47
48 // going through each character on top level
49 vector<string> finalOutput;
50 for(int i = 0; i<charToLetter[digits[0]].size(); ++i)
51     foo(i, 0, digits, "", finalOutput, charToLetter);
52
53 // returning
54 cout << format("final-output = {}\n", finalOutput);
55
56 // return
57 return(0);
58
59 }

```

---

## 19. Remove Nth Node From End of List

Given the head of a linked list, remove the nth node from the end of the list and return its head.

### Examples

1. **Example 1:**

- Input: head = [1,2,3,4,5], n = 2
- Output: [1,2,3,5]

2. **Example 2:**

- Input: head = [1], n = 1
- Output: []

3. **Example 3:**

- Input: head = [1,2], n = 1
- Output: [1]

### Constraints

- The number of nodes in the list is sz.
- $1 \leq sz \leq 30$
- $0 \leq \text{Node.val} \leq 100$
- $1 \leq n \leq sz$

## Code

---

```
1  int main(){
2
3      // starting timer
4      Timer timer;
5
6      // input- configuration
7      ListNode* head          = new ListNode(1);
8      head->next               = new ListNode(2);
9      head->next->next          = new ListNode(3);
10     head->next->next->next      = new ListNode(4);
11     head->next->next->next->next = new ListNode(5);
12     auto n {2};
13
14     // trivial case
15     if (!head) {cout << format("final-output = "); fPrintLinkedList(head); cout << endl;}
16
17     // setup
18     auto nodecounter {0};
19     auto prehead      {new ListNode};
20
21     prehead->next      = head;
22     ListNode* traveller = head;
23     ListNode* delayedTraveller = prehead;
24
25     // going through the list
26     while(traveller){
27         if (++nodecounter > n) {delayedTraveller = delayedTraveller->next;}
28         traveller = traveller->next;
29     }
30
31     // reconnecting
32     delayedTraveller->next = delayedTraveller->next->next;
33 }
```

```
34 // sending back
35 cout << format("final-output = ");
36 fPrintLinkedList(prehead->next); cout << endl;
37
38
39
40
41
42 // return
43 return(0);
44
45 }
```

---

## 20. Valid Parentheses

Given a string *s* containing just the characters '(', ')', '{', '}', '[', and ']', determine if the input string is valid.

An input string is valid if:

1. Open brackets must be closed by the same type of brackets.
2. Open brackets must be closed in the correct order.
3. Every close bracket has a corresponding open bracket of the same type.

### Examples

#### 1. Example 1:

- Input: *s* = "()"
- Output: true

#### 2. Example 2:

- Input: *s* = "()[]"
- Output: true

#### 3. Example 3:

- Input: *s* = "()["
- Output: false



## Constraints

- $1 \leq s.length \leq 10^4$
- s consists of parentheses only '()[]'.

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     string s  {"() [] {}"};
8
9     // seutp
10    deque<char> var00;
11
12    // going through the string
13    for(auto x: s){
14        // pushing or poppping
15        if (x == '(' || x == '[' || x == '{') {var00.push_back(x);}
16        else{
17            if (var00.size()==0) {cout << format("final-output = false\n"); return 0;}
18            if (x == ')') && var00.back() == '(') {var00.pop_back(); continue;}
19            if (x == ']') && var00.back() == '[') {var00.pop_back(); continue;}
20            if (x == '}') && var00.back() == '{') {var00.pop_back(); continue;}
21            cout << format("final-output = false\n"); return 0;
22        }
23    }
24
25    // checking if anything is left
```

```
26     if (var00.size()!=0) {cout << format("final-output = false\n"); return 0;}
27
28
29     // true-case
30     cout << format("final-output = true\n"); return 0;
31
32     // return
33     return(0);
34
35 }
```

---

## 21. 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.

### Examples

#### 1. Example 1:

- Input: `list1 = [1,2,4]`, `list2 = [1,3,4]`
- Output: `[1,1,2,3,4,4]`

#### 2. Example 2:

- Input: `list1 = []`, `list2 = []`
- Output: `[]`

#### 3. Example 3:

- Input: `list1 = []`, `list2 = [0]`
- Output: `[0]`

### Constraints

- The number of nodes in both lists is in the range `[0, 50]`.

- $-100 \leq \text{Node.val} \leq 100$
- Both list1 and list2 are sorted in non-decreasing order.

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     ListNode* list1 = new ListNode(1);
8     list1->next      = new ListNode(2);
9     list1->next->next = new ListNode(4);
10
11     ListNode* list2 = new ListNode(1);
12     list2->next      = new ListNode(3);
13     list2->next->next = new ListNode(4);
14
15     // setup
16     ListNode* finalOutput = new ListNode;
17     ListNode* traveller_final = finalOutput;
18     ListNode* traveller_1 = list1;
19     ListNode* traveller_2 = list2;
20
21     // going through the two lists
22     while (traveller_1 != nullptr && traveller_2 != nullptr) {
23
24         // comparing values
25         if (traveller_1->val < traveller_2->val) {
26             traveller_final->next = traveller_1;           // linking node to final
27             traveller_final        = traveller_final->next; // moving node to new link
```

```

28
29     if (traveller_1->next != nullptr)
30         traveller_1          = traveller_1->next;    // updating traveller 1
31     else{
32         traveller_1 = nullptr;
33         break;
34     }
35
36 }
37 else {
38     traveller_final->next = traveller_2;    // linking node to final
39     traveller_final      = traveller_final->next; // moving node to new link
40     if (traveller_2->next != nullptr)
41         traveller_2      = traveller_2->next;    // updating travel 2
42     else{
43         traveller_2 = nullptr;
44         break;
45     }
46 }
47 }
48
49 // checking if anything is left
50 while (traveller_1 != nullptr){
51     traveller_final->next = traveller_1;
52     traveller_final      = traveller_final->next;
53     traveller_1          = traveller_1->next;
54 }
55
56 while (traveller_2 != nullptr){
57     traveller_final->next = traveller_2;
58     traveller_final      = traveller_final->next;
59     traveller_2          = traveller_2->next;
60 }
61
62 // printing the final-output

```

```
63     cout << format("finaloutput = ");
64     fPrintLinkedList(finalOutput); cout << endl;
65
66     // return
67     return(0);
68 }
```

---

## 22. Generate Parentheses

Given  $n$  pairs of parentheses, write a function to generate all combinations of well-formed parentheses.

### Examples

#### 1. Example 1:

- Input:  $n = 3$
- Output: ["((()))", "(()())", "(())()", "()(())", "()()()"]

#### 2. Example 2:

- Input:  $n = 1$
- Output: ["()"]

### Constraints

- $1 \leq n \leq 8$

### Code

---

```
1 void foo(int          numopens,  
2     int          numcloses,  
3     const int&     n,  
4     string        runningstring,  
5     vector<string>& finalOutput){
```

```

6
7 // sending it back
8 if (numopens > n || numcloses > n) return;
9 else if (numopens == n && numcloses == n) {finalOutput.push_back(runningstring); return;}
10
11 // opening route
12 foo(numopens+1, numcloses, n, runningstring + "(", finalOutput);
13
14 // closing route
15 if (numopens>numcloses)
16     foo(numopens, numcloses+1, n, runningstring+")", finalOutput);
17
18 // returning
19 return;
20
21 }
22
23 int main(){
24
25     // starting timer
26     Timer timer;
27
28     // input- configuration
29     auto n {3};
30
31     // trivial case
32     if (n == 0) {cout << format("finalOutput = []\n"); return 0;}
33
34     // calling the function
35     vector<string> finalOutput;
36     foo(0, 0, n, "", finalOutput);
37
38     // returning
39     cout << format("finalOutput = {}\n", finalOutput);
40

```



```
41     // return
42     return(0);
43
44 }
```

---

## 23. Merge k Sorted Lists

You are given an array of k linked-lists lists, each linked-list is sorted in ascending order.

Merge all the linked-lists into one sorted linked-list and return it.

### Examples

#### 1. Example 1:

- Input: lists = [[1,4,5],[1,3,4],[2,6]]
- Output: [1,1,2,3,4,4,5,6]
- Explanation: The linked-lists are:  
1→4→5,  
1→3→4,  
2→6.  
• merging them into one sorted linked list: 1→1→2→3→4→4→5→6

#### 2. Example 2:

- Input: lists = []
- Output: []

#### 3. Example 3:

- Input: lists = [[]]
- Output: []

## Constraints

- $k == \text{lists.length}$
- $0 \leq k \leq 104$
- $0 \leq \text{lists}[i].\text{length} \leq 500$
- $-10^4 \leq \text{lists}[i][j] \leq 10^4$
- $\text{lists}[i]$  is sorted in ascending order.
- The sum of  $\text{lists}[i].\text{length}$  will not exceed  $10^4$ .

## Code

---

```
1 // main-file =====
2 int main(){
3
4     // starting timer
5     Timer timer;
6
7     // input- configuration
8     auto head0 {new ListNode(1)};
9     head0->next = new ListNode(4);
10    head0->next->next = new ListNode(5);
11
12    auto head1 {new ListNode(1)};
13    head1->next = new ListNode(3);
14    head1->next->next = new ListNode(4);
15
16    auto head2 {new ListNode(2)};
17    head2->next = new ListNode(6);
```

```

18
19 vector<ListNode*> lists {head0, head1, head2};
20
21
22 // setup
23 ListNode* prehead = new ListNode();
24 ListNode* traveller {prehead};
25 bool runcondition {true};
26 vector<ListNode*> travellerList;
27 int smallestindex {-1};
28 int smallestvalue {std::numeric_limits<int>::max()};
29
30 // filling up the traveller lists
31 for(int i = 0; i<lists.size(); ++i) {travellerList.push_back(lists[i]);}
32
33 // running the loop
34 int counter {0};
35 while(runcondition){
36
37     // going through the values
38     for(int i = 0; i < travellerList.size(); ++i){
39         if (travellerList[i] != nullptr &&
40             travellerList[i]->val < smallestvalue) {
41             smallestvalue = travellerList[i]->val;
42             smallestindex = i;
43         }
44     }
45
46     // now that we have the smallest value and smallest index, we add to the prehead
47     if (smallestindex == -1) {break;}
48     traveller->next = travellerList[smallestindex];
49     traveller = traveller->next;
50     travellerList[smallestindex] = travellerList[smallestindex]->next;
51
52     // resetting

```

```
53     smallestvalue = std::numeric_limits<int>::max();
54     smallestindex = -1;
55 }
56
57 // printing the final-linked list
58 fPrintLinkedList("final-output = ", prehead->next);
59
60 // return
61 return(0);
62
63 }
```

---

## 24. Swap Nodes in Pairs

Given a linked list, swap every two adjacent nodes and return its head. You must solve the problem without modifying the values in the list's nodes (i.e., only nodes themselves may be changed.)

### Examples

#### 1. Example 1:

- Input: head = [1,2,3,4]
- Output: [2,1,4,3]

#### 2. Example 2:

- Input: head = []
- Output: []

#### 3. Example 3:

- Input: head = [1]
- Output: [1]

### Constraints

- The number of nodes in the list is in the range [0, 100].
- $0 \leq \text{Node.val} \leq 100$

## Code

---

```
1  int main(){
2
3      // starting timer
4      Timer timer;
5
6      // input- configuration
7      auto head          {new ListNode(1)};
8      head->next          = new ListNode(2);
9      head->next->next     = new ListNode(3);
10     head->next->next->next = new ListNode(4);
11
12     // setup
13     ListNode* prehead   = new ListNode;
14     prehead->next        = head;
15     ListNode* traveller = prehead;
16
17     // going through it
18     while(traveller){
19
20         // jump-condition
21         if (traveller->next == nullptr || traveller->next->next == nullptr) break;
22
23         // swapping
24         if (traveller->next      != nullptr && traveller->next->next != nullptr){
25
26             ListNode* a  = traveller->next;
27             ListNode* b  = traveller->next->next;
28             ListNode* c  = traveller->next->next->next;
29
30             traveller->next = b;
31             b->next        = a;
32             a->next        = c;
33             traveller      = a;
```

```
34     }
35 }
36
37 // printing the linked List
38 fPrintLinkedList("final-output = ", prehead->next);
39
40 // return
41 return(0);
42
43 }
```

---



## 25. Reverse Nodes in k-Group

Given the head of a linked list, reverse the nodes of the list k at a time, and return the modified list.

k is a positive integer and is less than or equal to the length of the linked list. If the number of nodes is not a multiple of k then left-out nodes, in the end, should remain as it is.

You may not alter the values in the list's nodes, only nodes themselves may be changed.

### Examples

#### 1. Example 1:

- Input: head = [1,2,3,4,5], k = 2
- Output: [2,1,4,3,5]

#### 2. Example 2:

- Input: head = [1,2,3,4,5], k = 3
- Output: [3,2,1,4,5]

### Constraints

- The number of nodes in the list is n.
- $1 \leq k \leq n \leq 5000$
- $0 \leq \text{Node.val} \leq 1000$

## Code

---

```
1  int main(){
2
3      // starting timer
4      Timer timer;
5
6      // input- configuration
7      auto head          {new ListNode(1)};
8      head->next          = new ListNode(2);
9      head->next->next     = new ListNode(3);
10     head->next->next->next = new ListNode(4);
11     head->next->next->next->next = new ListNode(5);
12     auto k {2};
13
14     // setup
15     auto prehead        {new ListNode()};
16     prehead->next        = head;
17     auto traveller      {prehead};
18     vector<ListNode*> memberList(k, nullptr);
19     memberList.reserve(k);
20
21     // runnings
22     while(traveller){
23
24         // filling up the memberList
25         auto counter {0};
26         auto tempotraveller {traveller->next};
27
28         while(counter < k && tempotraveller != nullptr){
29             memberList[counter] = tempotraveller;
30             tempotraveller      = tempotraveller->next;
31             ++counter;
32         }
33     }
```

```

34     // checking breaking condition
35     if (counter!=k) break;
36
37     // reconnecting
38     auto beginningOfNextSegment {memberList[memberList.size()-1]->next};
39
40     // reconnecting
41     traveller->next = memberList[memberList.size()-1];
42     for(int i = memberList.size()-1; i>=1; --i) {memberList[i]->next = memberList[i-1];}
43     memberList[0]->next = beginningOfNextSegment;
44
45     // updating traveller
46     traveller = memberList[0];
47 }
48
49 // returning
50 fPrintLinkedList("final-output = ", prehead->next);
51
52 // return
53 return(0);
54
55 }

```

---

## 26. Remove Duplicates From Sorted Array

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`.

### Examples

#### 1. Example 1:

- Input: `nums = [1,1,2]`
- Output: 2, `nums = [1,2,_]`
- Explanation: Your function should return `k = 2`, with the first two elements of `nums` being 1 and 2 respectively. It does not matter what you leave beyond the returned `k` (hence they are underscores).

#### 2. Example 2:

- Input: `nums = [0,0,1,1,1,2,2,3,3,4]`
- Output: 5, `nums = [0,1,2,3,4,_,_,_,_,_]`
- Explanation: Your function should return `k = 5`, with the first five elements of `nums` being 0, 1, 2, 3, and 4 respectively. It does not matter what you leave beyond the returned `k` (hence they are underscores).

## Constraints:

- $1 \leq \text{nums.length} \leq 3 * 10^4$
- $-100 \leq \text{nums}[i] \leq 100$
- nums is sorted in non-decreasing order.

## Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> nums    {1,1};
5
6     // setup
7     int p    {0};
8     int counter {0};
9
10    // going through the values
11    for(int i = 1; i<nums.size(); ++i){
12
13        // check values
14        if (nums[i] == nums[p]) {continue;}
15
16        // writing values
17        ++p;
18        nums[p] = nums[i];
19        ++counter;
20    }
21
22    // printing the final output
23    cout << format("final-output = {}\n", counter+1);
```

```
24     cout << format("nums = "); fpv(nums);
25
26     // return
27     return(0);
28
29 }
```

---

## 27. Remove Element

Given an integer array `nums` and an integer `val`, remove all occurrences of `val` in `nums` in-place. The order of the elements may be changed. Then return the number of elements in `nums` which are not equal to `val`.

Consider the number of elements in `nums` which are not equal to `val` 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 elements which are not equal to `val`. The remaining elements of `nums` are not important as well as the size of `nums`. Return `k`.

### Examples

#### 1. Example 1:

- Input: `nums = [3,2,2,3]`, `val = 3`
- Output: `2`, `nums = [2,2,_,_]`
- Explanation: Your function should return `k = 2`, with the first two elements of `nums` being `2`. It does not matter what you leave beyond the returned `k` (hence they are underscores).

#### 2. Example 2:

- Input: `nums = [0,1,2,2,3,0,4,2]`, `val = 2`
- Output: `5`, `nums = [0,1,4,0,3,_,_,_]`
- Explanation: Your function should return `k = 5`, with the first five elements of `nums` containing `0`, `0`, `1`, `3`, and `4`. Note that the five elements can be returned in any order. It does not matter what you leave beyond the returned `k` (hence they are underscores).

## Constraints

- $0 \leq \text{nums.length} \leq 100$
- $0 \leq \text{nums}[i] \leq 50$
- $0 \leq \text{val} \leq 100$

## Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> nums {0,1,2,2,3,0,4,2};
5     int val         {2};
6
7     // setup
8     int src         {0};
9     int dest        {0};
10    int numwrites {0};
11
12    // going through the indices
13    while(src < nums.size()){
14
15        // moving the dest until we find a val-position
16        while(nums[dest] != val) {++dest;}
17
18        // moving source until we find a non-val position after dest
19        src = std::max(src, dest+1);
20        while(nums[src] == val) {++src;};
21
22        // writing
23        if (dest < nums.size() && src < nums.size()){
```



```
24         nums[dest] = nums[src];
25         ++dest;
26         ++src;
27         ++numwrites;
28     }
29
30 }
31
32 // printing the length
33 cout << format("updated nums = "); fPrintVector(nums);
34 cout << format("finaloutput = {} \n", nums.size()-numwrites-1);
35
36 // return
37 return(0);
38
39 }
```

---

## 28. Find the Index of the First Occurrence in a String

Given two strings `needle` and `haystack`, return the index of the first occurrence of `needle` in `haystack`, or -1 if `needle` is not part of `haystack`.

### Examples

#### 1. Example 1:

- Input: `haystack = "sadbutsad"`, `needle = "sad"`
- Output: 0
- Explanation: "sad" occurs at index 0 and 6. The first occurrence is at index 0, so we return 0.

#### 2. Example 2:

- Input: `haystack = "leetcode"`, `needle = "leeto"`
- Output: -1
- Explanation: "leeto" did not occur in "leetcode", so we return -1.

### Constraints

- $1 \leq \text{haystack.length}, \text{needle.length} \leq 10^4$
- `haystack` and `needle` consist of only lowercase English characters.

## Code

---

```
1 int main(){
2
3     // input- configuration
4     string haystack {"leetcode"};
5     string needle {"leeto"};
6
7
8     // setup
9     int finaloutput {-1};
10    auto beginsearch = [haystack, needle](int currindex){
11        // starting search
12        if(currindex + needle.size() > haystack.size()) {return false;}
13
14        // checking if they're a subset
15        for(int i = 0; i<needle.size(); ++i){
16            if (haystack[currindex + i] != needle[i]) {return false;}
17        }
18
19        return true;
20    };
21
22    // going through
23    for(int i = 0; i < haystack.size(); ++i){
24
25        // begin search at each index
26        auto curroutput = beginsearch(i);
27
28        // writing final output, if a mach
29        if (curroutput) {finaloutput = i; break;}
30    }
31
32    // printing final output
33
```

```
34     cout << format("final-output = {}\n", finaloutput);
35
36     // return
37     return(0);
38
39 }
```

---

### 33. Search in Rotated Sorted Array

There is an integer array `nums` sorted in ascending order (with distinct values).

Prior to being passed to your function, `nums` is possibly left rotated at an unknown index  $k$  ( $1 \leq k < \text{nums.length}$ ) such that the resulting array is `[nums[k], nums[k+1], ..., nums[n-1], nums[0], nums[1], ..., nums[k-1]]` (0-indexed). For example, `[0,1,2,4,5,6,7]` might be left rotated by 3 indices and become `[4,5,6,7,0,1,2]`.

Given the array `nums` after the possible rotation and an integer `target`, return the index of `target` if it is in `nums`, or `-1` if it is not in `nums`.

You must write an algorithm with  $O(\log n)$  runtime complexity.

#### Examples

1. **Example 1:**

- Input: `nums = [4,5,6,7,0,1,2]`, `target = 0`
- Output: 4

2. **Example 2:**

- Input: `nums = [4,5,6,7,0,1,2]`, `target = 3`
- Output: -1

3. **Example 3:**

- Input: `nums = [1]`, `target = 0`
- Output: -1

## Constraints

- $1 \leq \text{nums.length} \leq 5000$
- $-10^4 \leq \text{nums}[i] \leq 10^4$
- All values of nums are unique.
- nums is an ascending array that is possibly rotated.
- $-10^4 \leq \text{target} \leq 10^4$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto nums {vector<int>{4,5,6,7,0,1,2}};
8     auto target {0};
9
10    // setup
11    auto left      {0};
12    auto right     {static_cast<int>(nums.size())-1};
13    auto mid       {-1};
14    auto finaloutput {-1};
15
16
17    // going through the array
18    while(left <= right){
19        // fetching mid-value
```

```

20     mid = (left + right)/2;
21     if (nums[mid] == target) {finaloutput = mid; break;}
22
23     // checking if the left is sorted
24     if(nums[left] <= nums[mid]){
25         // checking if the target is out of bounds
26         if (target < nums[left] || target > nums[mid]) {left = mid +1;}
27         else {right = mid -1;}
28     }
29     else{
30         // checking if target is out of bounds
31         if (target < nums[mid] || target > nums[right]) {right = mid -1;}
32         else {left = mid + 1;}
33     }
34 }
35
36 // returning negative one in case none of these works
37 cout << format("final-output = {}\n", finaloutput);
38
39 // return
40 return(0);
41
42 }

```

---

## 34. Find First and Last Position of Element in Sorted Array

Given an array of integers `nums` sorted in non-decreasing order, find the starting and ending position of a given target value.

If target is not found in the array, return `[-1, -1]`.

You must write an algorithm with  $O(\log n)$  runtime complexity.

### Examples

#### 1. Example 1:

- Input: `nums = [5,7,7,8,8,10]`, `target = 8`
- Output: `[3,4]`

#### 2. Example 2:

- Input: `nums = [5,7,7,8,8,10]`, `target = 6`
- Output: `[-1,-1]`

#### 3. Example 3:

- Input: `nums = []`, `target = 0`
- Output: `[-1,-1]`

### Constraints

- $0 \leq \text{nums.length} \leq 10^5$



- $-10^9 \leq \text{nums}[i] \leq 10^9$
- `nums` is a non-decreasing array.
- $-10^9 \leq \text{target} \leq 10^9$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto nums {vector<int>{5,7,7,8,8,10}};
8     auto target {8};
9
10    // setup
11    auto left    {0};
12    auto right   {static_cast<int>(nums.size())-1};
13    auto mid     {-1};
14    auto leftedge {-1};
15    auto rightedge {-1};
16    auto finaloutput {vector<int>{-1, -1}};
17
18    // trivial case
19    if (nums.size()==0) {cout << format("final-output = {}\n", finaloutput); return 0;}
20
21    // finding left-edge
22    while(left <= right){
23        mid = (left+right)/2;
24        if (nums[mid] < target)    {left = mid +1;}
25        else if (target < nums[mid]) {right = mid-1;}
```

```

26         else                                {leftedge = mid; right = mid-1;}
27     }
28
29     // finding right-edge
30     left = 0; right = nums.size()-1;
31     while(left <= right){
32         mid = (left+right)/2;
33         if (nums[mid] < target)    {left = mid +1;}
34         else if (target < nums[mid]) {right = mid-1;}
35         else                      {rightedge = mid; left = mid+1;}
36     }
37
38     // building final output
39     finaloutput = vector<int>{leftedge, rightedge};
40
41     // printing the final output
42     cout << format("final-output = {}\n", finaloutput);
43
44     // return
45     return(0);
46
47 }

```

---

## 35. Search Insert Position

Given a sorted array of distinct integers and a target value, return the index if the target is found. If not, return the index where it would be if it were inserted in order.

You must write an algorithm with  $O(\log n)$  runtime complexity.

### Examples

1. **Example 1:**

- Input: `nums = [1,3,5,6]`, `target = 5`
- Output: 2

2. **Example 2:**

- Input: `nums = [1,3,5,6]`, `target = 2`
- Output: 1

3. **Example 3:**

- Input: `nums = [1,3,5,6]`, `target = 7`
- Output: 4

### Constraints

- $1 \leq \text{nums.length} \leq 10^4$

- $-10^4 \leq \text{nums}[i] \leq 10^4$
- nums contains distinct values sorted in ascending order.
- $-10^4 \leq \text{target} \leq 10^4$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto nums {vector<int>{1, 3, 5, 6}};
8     auto target {5};
9
10    // setup
11    auto left    {0};
12    auto right   {static_cast<int>(nums.size())-1};
13    auto mid     {-1};
14    auto finaloutput {-1};
15
16    // running the loop
17    while(left<=right){
18
19        // updating mid
20        mid = (left +right)/2;
21
22        // checking if mid is the value
23        if (nums[mid] == target) {finaloutput = mid; cout << format("final-output = {}\n", finaloutput); return 0;}
24        else if(nums[mid]<target) {left = mid+1;}
25        else                      {right = mid-1;}
```

```
26     }
27
28
29     // returning the midvalue
30     finaloutput = left;
31     cout << format("final-output = {}\n", finaloutput);
32
33     // return
34     return(0);
35
36 }
```

---

## 36. Valid Sudoku

Determine if a 9 x 9 Sudoku board is valid. Only the filled cells need to be validated according to the following rules:

1. Each row must contain the digits 1-9 without repetition.
2. Each column must contain the digits 1-9 without repetition.
3. Each of the nine 3 x 3 sub-boxes of the grid must contain the digits 1-9 without repetition.

### Examples

#### 1. Example 1

- Input: board =  
• `[["5","3",".",".","","7",".",".","."],`  
• `["6",".",".","1","9","5",".",".","."],`  
• `[[".","9","8",".",".",".","6","."],`  
• `["8",".",".","6",".",".","3"],`  
• `["4",".","8",".","3",".","1"],`  
• `["7",".",".","2",".",".","6"],`  
• `[["6",".",".","2","8","."],`  
• `[[".",".","4","1","9",".","5"],`  
• `[[".",".","8",".","7","9"]]`  
• Output: true

#### 2. Example 2:

- Input: board =
  - `[["8","3",".",".","7",".",".",".","."]`
  - `,["6",".",".","1","9","5",".",".","."]`
  - `,[".","9","8",".",".","","6","."]`
  - `,["8",".",".","6",".",".","","3"]`
  - `,["4",".","","8",".","3",".","","1"]`
  - `,["7",".",".","2",".",".","","6"]`
  - `,[".","6",".",".","","2","8","."]`
  - `,[".","","4","1","9",".","","5"]`
  - `,[".",".","","8",".","","7","9"]]`
- Output: false
- Explanation: Same as Example 1, except with the 5 in the top left corner being modified to 8. Since there are two 8's in the top left 3x3 sub-box, it is invalid.

## Constraints

- `board.length == 9`
- `board[i].length == 9`
- `board[i][j]` is a digit 1-9 or '.'.

Note:

- A Sudoku board (partially filled) could be valid but is not necessarily solvable.
- Only the filled cells need to be validated according to the mentioned rules.

## Code

---

```
1 // main-file
2 int main(){
3
4     // input-configuration
5     vector< vector<char> > board;
6     board.push_back({'5','3','.','.','7','.','.','.','.'});
7     board.push_back({'6','.','.','1','9','5','.','.','.'});
8     board.push_back({'.','9','8','.','.','.','.','6','.'});
9     board.push_back({'8','.','.','.','6','.','.','.','3'});
10    board.push_back({'4','.','.','8','.','3','.','.','1'});
11    board.push_back({'7','.','.','.','2','.','.','.','6'});
12    board.push_back({'.','6','.','.','.','.','2','8','.'});
13    board.push_back({'.','','.','.','4','1','9','.','.','5'});
14    board.push_back({'.','.'.','.','.','8','.','.','7','9'});
15
16    // basic method
17    int xoffset, yoffset;
18    int row_local, col_local;
19
20    // lambda for converting char to inger
21    auto fConvert = [](char x) -> int {
22        if (x == '.') return -1;
23        else { return static_cast<int>(x - '0');}
24    };
25
26    // checking row and column entries
27    for(int i = 0; i < 9; ++i){
28
29        // register for each jumnn
30        vector<int> rowRegister(9, 0);
31        vector<int> colRegister(9, 0);
32        vector<int> blockRegister(9,0);
33
```



```

34 // going through each jump
35 for(int j = 0; j<9; ++j){
36
37     // along the row
38     int var00 = fConvert(board[i][j]);
39     if (var00 != -1) {if (++rowRegister[var00-1] > 1) return false;}
40
41     // down the column
42     var00 = fConvert(board[j][i]);
43     if (var00 !=-1) {if (++colRegister[var00-1] > 1) return false;}
44
45     // checking block
46     row_local = j / 3;
47     col_local = j % 3;
48     xoffset = i / 3;
49     yoffset = i % 3;
50
51     // calculating registers
52     var00 = fConvert(board[3*xoffset + row_local][col_local+3*yoffset]);
53     if (var00!=-1) {if (++blockRegister[var00-1]>1) return false;}
54 }
55 }
56
57 // returning true
58 return true;
59 }

```

---

## 39. Combination Sum

Given an array of distinct integers candidates and a target integer target, return a list of all unique combinations of candidates where the chosen numbers sum to target. You may return the combinations in any order.

The same number may be chosen from candidates an unlimited number of times. Two combinations are unique if the frequency of at least one of the chosen numbers is different.

The test cases are generated such that the number of unique combinations that sum up to target is less than 150 combinations for the given input.

### Examples

#### 1. Example 1:

- Input: candidates = [2,3,6,7], target = 7
- Output: [[2,2,3],[7]]
- Explanation:
  - 2 and 3 are candidates, and  $2 + 2 + 3 = 7$ . Note that 2 can be used multiple times.
  - 7 is a candidate, and  $7 = 7$ .
  - These are the only two combinations.

#### 2. Example 2:

- Input: candidates = [2,3,5], target = 8
- Output: [[2,2,2,2],[2,3,3],[3,5]]

#### 3. Example 3:

- Input: candidates = [2], target = 1
- Output: []

## Constraints

- $1 \leq \text{candidates.length} \leq 30$
- $2 \leq \text{candidates}[i] \leq 40$
- All elements of candidates are distinct.
- $1 \leq \text{target} \leq 40$

## Code

---

```
1 void foo(const vector<int>& candidates,
2         vector<int> runningvector,
3         const int& target,
4         vector<vector<int>>& finalOutput)
5 {
6     // calculating running sum
7     int runningsum = std::accumulate(runningvector.begin(),
8                                     runningvector.end(),
9                                     0);
10
11     // sending it back
12     if (runningsum > target) {return;}
13     if (runningsum == target) {finalOutput.push_back(runningvector); return;}
14
15     // going through the different options
16     for(auto x: candidates){
```

```

17
18     // checking if this should be
19     if (runningvector.size() != 0 && x < runningvector[runningvector.size()-1]) {continue;}
20
21     auto temp {runningvector};
22     temp.push_back(x);
23
24     // recursive-call
25     foo(candidates, temp, target, finalOutput);
26 }
27
28 // returning
29 return;
30 }
31 int main(){
32
33     // starting timer
34     Timer timer;
35
36     // input- configuration
37     auto candidates {vector<int>{2,3,6,7}};
38     auto target      {7};
39
40     // setup
41     vector<vector<int>> finalOutput;
42     vector<int>         runningvector;
43
44     // calling the function
45     foo(candidates, runningvector, target, finalOutput);
46
47     // returning
48     cout << format("final-output = {}\n", finalOutput);
49
50     // return
51     return(0);

```

52

53

}

## 41. First Missing Positive

Given an unsorted integer array `nums`. Return the smallest positive integer that is not present in `nums`.

You must implement an algorithm that runs in  $O(n)$  time and uses  $O(1)$  auxiliary space.

### Examples

#### 1. Example 1:

- Input: `nums = [1,2,0]`
- Output: 3
- Explanation: The numbers in the range `[1,2]` are all in the array.

#### 2. Example 2:

- Input: `nums = [3,4,-1,1]`
- Output: 2
- Explanation: 1 is in the array but 2 is missing.

#### 3. Example 3:

- Input: `nums = [7,8,9,11,12]`
- Output: 1
- Explanation: The smallest positive integer 1 is missing.

## Constraints

- $1 \leq \text{nums.length} \leq 10^5$
- $-2^{31} \leq \text{nums}[i] \leq 2^{31} - 1$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto nums {vector<int>{3,4,-1,1}};
8
9     // in the off-chance that minvalue is one, building ordered set of values
10    std::set<int> orderedvalues;
11    for(auto x: nums)        {if (x>0) orderedvalues.insert(x);}
12
13    // going through the ordered set
14    auto finaloutput {1};
15    auto flag        {0};
16    for(const auto& x: orderedvalues)
17        if (x - finaloutput++ != 0) {--finaloutput; break;}
18
19    // printing based on flag value
20    cout << format("final-output = {}\n", finaloutput);
21
22    // return
23    return(0);
24
25 }
```

---

## 42. Trapping Rain Water

Given  $n$  non-negative integers representing an elevation map where the width of each bar is 1, compute how much water it can trap after raining.

### Examples

#### 1. Example 1

- Input: `height = [0,1,0,2,1,0,1,3,2,1,2,1]`
- Output: 6
- Explanation: The above elevation map (black section) is represented by array `[0,1,0,2,1,0,1,3,2,1,2,1]`. In this case, 6 units of rain water (blue section) are being trapped.

#### 2. Example 2

- Input: `height = [4,2,0,3,2,5]`
- Output: 9

### Constraints

1.  $n == \text{height.length}$
2.  $1 \leq n \leq 2 * 10^4$
3.  $0 \leq \text{height}[i] \leq 10^5$



## Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> height {0,1,0,2,1,0,1,3,2,1,2,1};
5
6     // setup
7     vector<int> leftmaxes(height.size(), 0);
8     vector<int> rightmaxes(height.size(), 0);
9     int forwardindex {0};
10    int backwardindex {0};
11    int maxleft {-1};
12    int maxright {-1};
13    int finaloutput {0};
14
15    // building left-max
16    for(int i = 1; i<height.size(); ++i){
17
18        // calculating indices
19        forwardindex = i;
20        backwardindex = height.size()-1-i;
21
22        // calculating maxleft
23        maxleft = height[forwardindex-1] > maxleft ?
24                  height[forwardindex-1] : maxleft;
25        leftmaxes[forwardindex] = maxleft;
26
27        // calculating max right
28        maxright = height[backwardindex+1] > maxright ?
29                   height[backwardindex+1] : maxright;
30        rightmaxes[backwardindex] = maxright;
31    }
32
33    // going through the array to calculate maxvolume held by each column
```

```
// vector holding biggest-height to left
// vector holding biggest-height to the right
// for maintaining forward-index
// for maintaining backward-index
// keeping record of biggest left
// keeping record of biggest right
// storing final output

// forward-index
// backward-index

// running max-left
// storing to vector

// running max-right
// storing to vector
```

```

34 for(int i = 0; i < height.size(); ++i){
35
36     // finding max-height of the current column
37     auto minheight    = std::min({leftmaxes[i], rightmaxes[i]}); // finding max-height of borders
38     auto columnheight = minheight - height[i];                 // subtracting to find space
39     columnheight      = columnheight > 0 ? columnheight : 0;    // in case curr-height > max-height
40     finaloutput       += columnheight;                          // accumulating to water content
41 }
42
43 // printing the final output
44 cout << format("finaloutput = {}\n", finaloutput);
45
46 // return
47 return(0);
48
49 }

```

---

## 45 Jump Game II

You are given a 0-indexed array of integers `nums` of length `n`. You are initially positioned at index 0. Each element `nums[i]` represents the maximum length of a forward jump from index `i`. In other words, if you are at index `i`, you can jump to any index `(i + j)` where:

- $0 \leq j \leq \text{nums}[i]$
- $i + j \leq n$

Return the minimum number of jumps to reach index `n - 1`. The test cases are generated such that you can reach index `n - 1`.

### Examples

#### 1. Example 1

- Input: `nums = [2,3,1,1,4]`
- Output: 2
- Explanation: The minimum number of jumps to reach the last index is 2. Jump 1 step from index 0 to 1, then 3 steps to the last index.

#### 2. Example 2

- Input: `nums = [2,3,0,1,4]`
- Output: 2

## Constraints

- $1 \leq \text{nums.length} \leq 10^4$
- $0 \leq \text{nums}[i] \leq 1000$
- It's guaranteed that you can reach  $\text{nums}[\text{n} - 1]$ .

## Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> nums {2,3,0,1,4};
5
6     // setup
7     Timer timer;
8     vector<int> minjumps(nums.size(),0);
9     int leftboundary {-1};
10    int rightboundary {-1};
11
12    // moving from the back
13    for(int i = nums.size()-2; i>=0; --i){
14
15        // continuign if nums[i] = 0
16        if (nums[i] == 0) {
17            minjumps[i] = std::numeric_limits<int>::max();
18            continue;
19        }
20
21        // range of values it can go from here
22        leftboundary = i+1;
23        rightboundary = i+nums[i];
```

```
// setting a timer
// the dp table
// variable to hold the left-boundary
// variable to hold the right-boundary
```

```
// to prevent this from being chosen
// moving to next index
```

```
// the starting point of range
// the end point of range
```

```

24     rightboundary = rightboundary < nums.size()-1 ?
25         rightboundary : nums.size()-1;                                // ensuring within vector range
26
27     // calculating smallest element in range
28     auto it = std::min_element(minjumps.begin()+leftboundary,
29                               minjumps.begin()+rightboundary+1);    // finding the minimum value in the range
30
31     // adding min-element to the array
32     if (*it == std::numeric_limits<int>::max())
33         minjumps[i] = std::numeric_limits<int>::max();                // ensuring infity logic
34     else
35         minjumps[i] = (1 + *it);                                       // for regular values
36
37 }
38
39 // printing
40 cout << format("finaloutput = {}\n", minjumps[0]);
41 timer.measure();
42
43 // return
44 return(0);
45
46 }

```

---

## 46. Permutations

Given an array `nums` of distinct integers, return all the possible permutations. You can return the answer in any order.

### Examples

1. **Example 1:**

- Input: `nums = [1,2,3]`
- Output: `[[1,2,3],[1,3,2],[2,1,3],[2,3,1],[3,1,2],[3,2,1]]`

2. **Example 2:**

- Input: `nums = [0,1]`
- Output: `[[0,1],[1,0]]`

3. **Example 3:**

- Input: `nums = [1]`
- Output: `[[1]]`

### Constraints

- $1 \leq \text{nums.length} \leq 6$
- $-10 \leq \text{nums}[i] \leq 10$
- All the integers of `nums` are unique.

## Code

---

```
1 // traversing function
2 void fRecursive(const std::vector<int>&      nums,      \
3               std::vector< std::vector<int> >& finalOutput, \
4               const std::vector<int>      path,      \
5               const std::vector<int>      numsleft){
6
7     // check if length is reached
8     if (path.size() == nums.size()){
9
10        // add to final output
11        if (std::find(finalOutput.begin(), finalOutput.end(), path) == finalOutput.end())
12            finalOutput.push_back(path);
13
14        // returning since the path is complete
15        return;
16    }
17
18    // choosing from numsleft
19    for(int i = 0; i<numsleft.size(); ++i){
20
21        // choosing a number,
22        auto num      {numsleft[i]};
23        auto pathtemp  {path};
24        pathtemp.push_back(num);
25
26        // making a copy of nums left, removing character
27        auto numsleft_temp  {numsleft};
28        numsleft_temp.erase(numsleft_temp.begin() + i);
29
30        // calling function
31        fRecursive(nums, finalOutput, pathtemp, numsleft_temp);
32    }
33
```

```
34     // returning results
35     return;
36 }
37
38 int main(){
39
40     // starting timer
41     Timer timer;
42
43     // input- configuration
44     auto nums {vector<int>{1,2,3}};
45
46     // setup
47     std::vector<std::vector<int>> finalOutput;
48     auto path {vector<int>{}};
49     auto numsleft {nums};
50
51     // calling the function
52     fRecursive(nums, finalOutput, path, numsleft);
53
54     // returning the output
55     cout << format("final-output = {}\n", finalOutput);
56
57     // return
58     return(0);
59 }
```

---



## 48. Rotate Image

You are given an  $n \times n$  2D matrix representing an image, rotate the image by 90 degrees (clockwise).

You have to rotate the image in-place, which means you have to modify the input 2D matrix directly. DO NOT allocate another 2D matrix and do the rotation.

### Examples

#### 1. Example 1:

- Input: matrix = `[[1,2,3],[4,5,6],[7,8,9]]`
- Output: `[[7,4,1],[8,5,2],[9,6,3]]`

#### 2. Example 2:

- Input: matrix = `[[5,1,9,11],[2,4,8,10],[13,3,6,7],[15,14,12,16]]`
- Output: `[[15,13,2,5],[14,3,4,1],[12,6,8,9],[16,7,10,11]]`

### Constraints

- $n == \text{matrix.length} == \text{matrix}[i].\text{length}$
- $1 \leq n \leq 20$
- $-1000 \leq \text{matrix}[i][j] \leq 1000$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     vector<vector<int>> matrix {
8         {1,2,3},
9         {4,5,6},
10        {7,8,9}
11    };
12
13    // setup
14    auto t_edge    {0};
15    auto b_edge    {static_cast<int>(matrix.size())-1};
16    auto l_edge    {0};
17    auto r_edge    {static_cast<int>(matrix[0].size())-1};
18    auto temp      {-1};
19
20    // shifting layer by layer.
21    int numlayers = (matrix.size())/2;
22
23    // shifting layer by layer
24    for(int i = 0; i<numlayers; ++i){
25
26        // breaking if they're the same for some reason
27        if(t_edge == b_edge || l_edge == r_edge) {break;}
28
29        // calculatin width
30        auto currwidth {r_edge - l_edge + 1};
31
32
33        for(int j = 0; j<currwidth-1; ++j){
```

```

34
35     // shifting the four elements for each
36     temp                = matrix[t_edge][l_edge+j];
37     matrix[t_edge][l_edge+j] = matrix[b_edge-j][l_edge];
38     matrix[b_edge-j][l_edge] = matrix[b_edge][r_edge-j];
39     matrix[b_edge][r_edge-j] = matrix[t_edge+j][r_edge];
40     matrix[t_edge+j][r_edge] = temp;
41 }
42
43     // updating edge-parameters based on the layer we're working with
44     t_edge += 1;
45     b_edge -= 1;
46     l_edge += 1;
47     r_edge -= 1;
48
49 }
50
51 // printing the matrix
52 cout << format("print-matrix\n");
53 fPrintMatrix(matrix);
54
55 // return
56 return(0);
57
58 }

```

---

## 49. Group Anagrams

Given an array of strings `strs`, group the anagrams together. You can return the answer in any order.

### Examples

#### 1. Example 1:

- Input: `strs = ["eat","tea","tan","ate","nat","bat"]`
- Output: `[["bat"],["nat","tan"],["ate","eat","tea"]]`
- Explanation:
  - There is no string in `strs` that can be rearranged to form `"bat"`.
  - The strings `"nat"` and `"tan"` are anagrams as they can be rearranged to form each other.
  - The strings `"ate"`, `"eat"`, and `"tea"` are anagrams as they can be rearranged to form each other.

#### 2. Example 2:

- Input: `strs = [""]`
- Output: `[[""]]`

#### 3. Example 3:

- Input: `strs = ["a"]`
- Output: `[["a"]]`

## Constraints

- $1 \leq \text{strs.length} \leq 10^4$
- $0 \leq \text{strs}[i].\text{length} \leq 100$
- $\text{strs}[i]$  consists of lowercase English letters.

## Code

---

```
1 // build histogram
2 vector<int> fBuildHist(string input){
3     vector<int> myhist(26, 0);
4     for(auto x: input) {++myhist[static_cast<int>(x - 'a')];}
5     return myhist;
6 }
7
8 // Custom hash function for vector<int>
9 struct VectorHash {
10     std::size_t operator()(const std::vector<int>& v) const {
11         std::size_t hashValue = 0;
12         for (int num : v)
13             hashValue ^= std::hash<int>{}(num) + 0x9e3779b9 + (hashValue << 6) + (hashValue >> 2);
14
15         return hashValue;
16     }
17 };
18 // int main
19 int main(){
20
21     // starting timer
22     Timer timer;
23 }
```

```

24 // input- configuration
25 vector<string> strs{
26     "eat",
27     "tea",
28     "tan",
29     "ate",
30     "nat",
31     "bat"
32 };
33
34 // unordered map for hist to vector of vector of strings
35 unordered_map< vector<int>, vector<string>, VectorHash > histToGroup;
36
37 for(auto x: strs){
38
39     // building hist of current word
40     auto xhist = fBuildHist(x);
41
42     // checking if it exists
43     if (histToGroup.find(xhist) == histToGroup.end())
44         histToGroup[xhist] = vector<string>({x});
45     else
46         histToGroup[xhist].push_back(x);
47
48 }
49
50 // building final output
51 vector<vector<string>> finalOutput;
52 for(auto x: histToGroup) {finalOutput.push_back(x.second);}
53
54 // printing
55 cout << format("final-output = {}\n", finalOutput);
56
57 // return
58 return(0);

```



## 50. Pow(x, n)

Implement  $\text{pow}(x, n)$ , which calculates  $x$  raised to the power  $n$  (i.e.,  $x^n$ ).

### Examples

#### 1. Example 1:

- Input:  $x = 2.00000$ ,  $n = 10$
- Output: 1024.00000

#### 2. Example 2:

- Input:  $x = 2.10000$ ,  $n = 3$
- Output: 9.26100

#### 3. Example 3:

- Input:  $x = 2.00000$ ,  $n = -2$
- Output: 0.25000
- Explanation:  $2^{-2} = 1/2^2 = 1/4 = 0.25$

### Constraints

- $-100.0 < x < 100.0$
- $-2^{31} \leq n \leq 2^{31} - 1$



- $n$  is an integer.
- Either  $x$  is not zero or  $n \neq 0$ .
- $-10^4 \leq x^n \leq 10^4$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto x {2.00000};
8     auto n {10};
9
10    // setup
11    std::function<double(double, long int)> foo = [&foo](
12        double    x,
13        long int   n) -> double
14    {
15
16        // base-cases
17        if (x == 0)    {return 0;}
18        if (n == 0)    {return 1;}
19
20        // performing calculations
21        double result = foo(x, n/2);
22        result = result * result;
23
24        // in case there is some odd-wor
25        if (n%2 == 1) {result = result * x;}
```

```
26
27     // returning the results
28     return result;
29
30 };
31
32 // calling the function
33 auto finalresult = foo(x, std::abs(static_cast<long int>(n)));
34
35 // taking care of the negative case
36 if (n < 0) {finalresult = static_cast<double>(1)/finalresult;}
37
38 // returning the final result
39 cout << format("final-output = {}\n", finalresult);
40
41 // return
42 return(0);
43
44 }
```

---

## 53. Maximum Subarray

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

### Examples

#### 1. Example 1:

- Input: `nums = [-2,1,-3,4,-1,2,1,-5,4]`
- Output: 6
- Explanation: The subarray `[4,-1,2,1]` has the largest sum 6.

#### 2. Example 2:

- Input: `nums = [1]`
- Output: 1
- Explanation: The subarray `[1]` has the largest sum 1.

#### 3. Example 3:

- Input: `nums = [5,4,-1,7,8]`
- Output: 23
- Explanation: The subarray `[5,4,-1,7,8]` has the largest sum 23.

## Constraints

- $1 \leq \text{nums.length} \leq 10^5$
- $-10^4 \leq \text{nums}[i] \leq 10^4$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto nums    {vector<int>({-2,1,-3,4,-1,2,1,-5,4})};
8
9     // setup
10    auto runningsum {0};
11    auto finaloutput {std::numeric_limits<int>::min()};
12
13    // going through the array
14    for(int i =0; i<nums.size(); ++i){
15        runningsum += nums[i];
16        finaloutput = std::max(runningsum, finaloutput);
17        if (runningsum <0) {runningsum = 0;}
18    }
19
20    // printing the final output
21    cout << format("finaloutput = {}\n", finaloutput);
22
23    // return
24    return(0);
25}
```



## 54. Spiral Matrix

Given an  $m \times n$  matrix, return all elements of the matrix in spiral order.

### Examples

#### 1. Example 1:

- Input: matrix = [[1,2,3],[4,5,6],[7,8,9]]
- Output: [1,2,3,6,9,8,7,4,5]

#### 2. Example 2:

- Input: matrix = [[1,2,3,4],[5,6,7,8],[9,10,11,12]]
- Output: [1,2,3,4,8,12,11,10,9,5,6,7]

### Constraints

- $m == \text{matrix.length}$
- $n == \text{matrix}[i].\text{length}$
- $1 \leq m, n \leq 10$
- $-100 \leq \text{matrix}[i][j] \leq 100$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     vector<vector<int>> matrix{
8         {1,2,3,4},
9         {5,6,7,8},
10        {9,10,11,12}
11    };
12
13    // setup
14    int left {0};
15    int right {static_cast<int>(matrix[0].size()-1)};
16    int top {0};
17    int bottom {static_cast<int>(matrix.size()-1)};
18    vector<int> finalOutput;
19
20    // moving through this
21    while(left <= right && top <= bottom){
22
23        // moving on upside
24        for(int i = left; i <= right; ++i) {finalOutput.push_back(matrix[top][i]);}
25
26        // moving through the right side
27        for(int i = top+1; i<=bottom-1; ++i) {finalOutput.push_back(matrix[i][right]);}
28
29        // moving through the bottom
30        for(int i = right; top != bottom && i>= left; --i) {finalOutput.push_back(matrix[bottom][i]);}
31
32        // moving through the left
33        for(int i = bottom-1; left!=right && i>= top+1; --i) {finalOutput.push_back(matrix[i][left]);}
```

```
34
35     // updating boundaries
36     ++left; --right; ++top; --bottom;
37
38 }
39
40 // printing the finaloutput
41 cout << format("final-output = {}\n", finalOutput);
42
43 // return
44 return(0);
45
46 }
```

---



## 55. Jump Game

You are given an integer array `nums`. You are initially positioned at the array's first index, and each element in the array represents your maximum jump length at that position. Return `true` if you can reach the last index, or `false` otherwise.

### Examples

#### 1. Example 1

- Input: `nums = [2,3,1,1,4]`
- Output: `true`
- Explanation: Jump 1 step from index 0 to 1, then 3 steps to the last index.

#### 2. Example 2

- Input: `nums = [3,2,1,0,4]`
- Output: `false`
- Explanation: You will always arrive at index 3 no matter what. Its maximum jump length is 0, which makes it impossible to reach the last index.

### Constraints

- $1 \leq \text{nums.length} \leq 10^4$
- $0 \leq \text{nums}[i] \leq 10^5$

## Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> nums {3,2,1,0,4};
5
6     // setup
7     Timer timer;                                // starting a timer
8     int maxjumpdistance {0};                    // variable holding max-jump-distance
9     int currjumpdistance {0};                  // variable holding max-jump-distance from here
10    int finaloutput {0};                        // variable holding final verdict
11
12    // going through the nums
13    for(int i = 0; i<=maxjumpdistance && i<nums.size(); ++i){
14
15        // calculating max-distance we can go from here
16        currjumpdistance = i + nums[i];
17
18        // updating max-jumpdistance
19        maxjumpdistance = currjumpdistance > maxjumpdistance ? \
20            currjumpdistance : maxjumpdistance;
21
22    }
23
24    // updating the final output
25    finaloutput = maxjumpdistance >= nums.size()-1 ? true : false;
26
27    // printing the thing
28    cout << format("final-output = {}\n", finaloutput);
29    timer.measure();
30
31
32    // return
33    return(0);
```

34

35

}

---

## 56. Merge Intervals

Given an array of intervals where  $\text{intervals}[i] = [\text{start}_i, \text{end}_i]$ , merge all overlapping intervals, and return an array of the non-overlapping intervals that cover all the intervals in the input.

### Examples

#### 1. Example 1:

- Input:  $\text{intervals} = [[1,3],[2,6],[8,10],[15,18]]$
- Output:  $[[1,6],[8,10],[15,18]]$
- Explanation: Since intervals  $[1,3]$  and  $[2,6]$  overlap, merge them into  $[1,6]$ .

#### 2. Example 2:

- Input:  $\text{intervals} = [[1,4],[4,5]]$
- Output:  $[[1,5]]$
- Explanation: Intervals  $[1,4]$  and  $[4,5]$  are considered overlapping.

### Constraints

- $1 \leq \text{intervals.length} \leq 104$
- $\text{intervals}[i].\text{length} == 2$
- $0 \leq \text{start}_i \leq \text{end}_i \leq 104$

## Code

---

```
1  int main(){
2
3      // starting timer
4      Timer timer;
5
6      // input- configuration
7      vector<vector<int>> intervals{
8          {1,3},
9          {2,6},
10         {8,10},
11         {15,18}
12     };
13
14     // setup
15     vector<vector<int>> finalOutput;
16
17     // sorting the input
18     std::sort(intervals.begin(), intervals.end(),
19         [](const vector<int>& a, const vector<int>& b){return a[0] < b[0];});
20
21     // going through the intervals
22     vector<int> runninginterval {intervals[0][0], intervals[0][1]};
23     for(int i = 1; i<intervals.size(); ++i){
24         if (runninginterval[1] < intervals[i][0]){
25             finalOutput.push_back(runninginterval);           // pushing the results
26             runninginterval = intervals[i];                   // getting new running interval
27         }
28         else {runninginterval[1] = max(runninginterval[1], intervals[i][1]);}
29     }
30     finalOutput.push_back(runninginterval);                   // pushing the results
31
32     // returning
33     cout << format("final-output = {}\n", finalOutput);
```

```
34
35 // return
36 return(0);
37 }
```

---

## 57. Insert Interval

You are given an array of non-overlapping intervals `intervals` where `intervals[i] = [starti, endi]` represent the start and the end of the *i*th interval and `intervals` is sorted in ascending order by `starti`. You are also given an interval `newInterval = [start, end]` that represents the start and end of another interval.

Insert `newInterval` into `intervals` such that `intervals` is still sorted in ascending order by `starti` and `intervals` still does not have any overlapping intervals (merge overlapping intervals if necessary).

Return `intervals` after the insertion.

Note that you don't need to modify `intervals` in-place. You can make a new array and return it.

### Examples

#### 1. Example 1:

- Input: `intervals = [[1,3],[6,9]]`, `newInterval = [2,5]`
- Output: `[[1,5],[6,9]]`

#### 2. Example 2:

- Input: `intervals = [[1,2],[3,5],[6,7],[8,10],[12,16]]`, `newInterval = [4,8]`
- Output: `[[1,2],[3,10],[12,16]]`
- Explanation: Because the new interval `[4,8]` overlaps with `[3,5]`, `[6,7]`, `[8,10]`.

### Constraints

- $0 \leq \text{intervals.length} \leq 10^4$

- `intervals[i].length == 2`
- $0 \leq \text{start}_i \leq \text{end}_i \leq 10^5$
- `intervals` is sorted by `start_i` in ascending order.
- `newInterval.length == 2`
- $0 \leq \text{start} \leq \text{end} \leq 10^5$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     vector<vector<int>> intervals{
8         {1,2},
9         {3,5},
10        {6,7},
11        {8,10},
12        {12,16}
13    };
14    vector<int> newInterval{4,8};
15
16
17    // setup
18    vector<vector<int>> finalOutput;
19    intervals.push_back(newInterval);
20
21    // sorting the interval
```



```

22     std::sort(intervals.begin(),
23             intervals.end(),
24             [](const vector<int>& a,
25               const vector<int>& b){return a[0] < b[0];});
26     vector<int>      runninginterval {intervals[0]};
27
28     // going through the inputs
29     for(int i = 1; i<intervals.size(); ++i){
30         if (runninginterval[1] < intervals[i][0]){
31             finalOutput.push_back(runninginterval);
32             runninginterval = intervals[i];
33         }
34         else{
35             runninginterval[1] = max(runninginterval[1], intervals[i][1]);
36         }
37     }
38
39     // pushing it back
40     finalOutput.push_back(runninginterval);
41     cout << format("final-output = {}\n", finalOutput);
42
43     // return
44     return(0);
45
46 }

```

---

## 58. Length of Last Word

Given a string *s* consisting of words and spaces, return the length of the last word in the string. A word is a maximal substring consisting of non-space characters only.

### Example

#### 1. Example 1:

- Input: *s* = "Hello World"
- Output: 5
- Explanation: The last word is "World" with length 5.

#### 2. Example 2:

- Input: *s* = " fly me to the moon "
- Output: 4
- Explanation: The last word is "moon" with length 4.

#### 3. Example 3:

- Input: *s* = "luffy is still joyboy"
- Output: 6
- Explanation: The last word is "joyboy" with length 6.

## Constraints

- $1 \leq \text{s.length} \leq 10^4$
- s consists of only English letters and spaces ' '.
- There will be at least one word in s.

## Code

---

```
1 int main(){
2
3     // input- configuration
4     string s  {" fly me to the moon "};
5
6     // setup
7     int p1    {-1};
8     int finaloutput {-1};
9     string laststring;
10
11    // moving from the end
12    for(int i = s.size()-1; i>=0; --i){
13
14        // continuing until you find a non-space character
15        if (s[i] == ' ') {continue;}
16
17        // launch the start of first word
18        p1 = i;
19
20        // moving p1 until we find the first space or nonword thing
21        while(p1>0 && s[p1]!=' '){--p1;}
22
23        // calculating the length
```

```
24     finaloutput = i - p1;
25     laststring = string(s.begin() + p1, s.begin() + i+1);
26
27     // breaking
28     break;
29 }
30
31 // printing
32 cout << format("length = {}, last-word = {}\n", finaloutput, laststring);
33
34 // return
35 return(0);
36
37 }
```

---

## 60. Permutation Sequence

The set  $[1, 2, 3, \dots, n]$  contains a total of  $n!$  unique permutations.

By listing and labeling all of the permutations in order, we get the following sequence for  $n = 3$

- "123"
- "132"
- "213"
- "231"
- "312"
- "321"

Given  $n$  and  $k$ , return the  $k$ th permutation sequence.

### Examples

#### 1. Example 1

- Input:  $n = 3, k = 3$
- Output: "213"

#### 2. Example 2

- Input:  $n = 4, k = 9$

- Output: "2314"

### 3. Example 3

- Input:  $n = 3, k = 1$
- Output: "123"

## Constraints

- $1 \leq n \leq 9$
- $1 \leq k \leq n!$

## Code

---

```
1 string vectortostr(const vector<int>& pathsofar){
2     auto temp {string("")};
3     for(int i = 0; i<pathsofar.size(); ++i) {temp += std::to_string(pathsofar[i]);}
4     return temp;
5 }
6
7 void foo(vector<int>          pathsofar,
8         const int&          n,
9         int                curr,
10        int&                 leafcount,
11        const int&           k,
12        string&              finaloutput,
13        bool&                 found){
14
15     // sending it back
16     if (found == true) {return;}
```

```

17
18 // adding current number to pathsofar
19 if (std::find(pathsofar.begin(), pathsofar.end(), curr) != pathsofar.end()) {return;}
20
21 // adding to the path
22 pathsofar.push_back(curr);
23
24 // checking if we've reached a leaf
25 if (pathsofar.size() == n) {
26     ++leafcount;
27     if (leafcount == k) {
28         finaloutput = vectortostring(pathsofar);
29         found = true;
30     }
31     return;
32 }
33
34 // calling on the others
35 for(int i = 1; i<=n; ++i) {foo(pathsofar, n, i, leafcount, k, finaloutput, found);}
36 }
37
38 int main(){
39
40     // starting timer
41     Timer timer;
42
43     // input- configuration
44     auto n {8};
45     auto k {29805};
46
47     // setup
48     auto finaloutput {string("")};
49     auto found {false};
50
51     // building the directing block

```

```

52 auto directionalblocks {vector<int>(n-1, 1)};
53 for(int i = directionalblocks.size()-2; i >= 0; --i)
54     directionalblocks[i] = directionalblocks[i+1] * (directionalblocks.size()-i);
55
56 // printing
57 auto startingpoint {k/directionalblocks[0]};
58 startingpoint = std::max(startingpoint, 1);
59
60 // printing the leaf
61 auto leafcount    {directionalblocks[0] * (startingpoint-1)};
62
63 // running
64 for(int i = startingpoint; i<=n; ++i){
65     vector<int> pathsofar;
66     foo(pathsofar, n, i, leafcount, k, finaloutput, found);
67 }
68
69 // printing the final-output
70 cout << format("final-output = {}\n", finaloutput);
71
72 // return
73 return(0);
74 }

```

---



## 61. Rotate List

Given the head of a linked list, rotate the list to the right by  $k$  places.

### Examples

#### 1. Example 1:

- Input: head = [1,2,3,4,5],  $k = 2$
- Output: [4,5,1,2,3]

#### 2. Example 2:

- Input: head = [0,1,2],  $k = 4$
- Output: [2,0,1]

### Constraints

- The number of nodes in the list is in the range [0, 500].
- $-100 \leq \text{Node.val} \leq 100$
- $0 \leq k \leq 2 * 10^9$

## Code

---

```
1  int main(){
2
3      // starting timer
4      Timer timer;
5
6      // input- configuration
7      auto head {new ListNode(1)};
8      head->next = new ListNode(2);
9      head->next->next = new ListNode(3);
10     head->next->next->next = new ListNode(4);
11     head->next->next->next->next = new ListNode(5);
12     auto k {2};
13
14     // trivial cases
15     if (head == nullptr) {fPrintLinkedList("head = ", head); return 0;}
16
17     // storing the starting point
18     auto startingpoint {head};
19     auto listsize      {0};
20
21     // connecting the last-node with the first
22     auto traveller {head};
23     while(traveller->next) {traveller = traveller->next; ++listsize;}
24     ++listsize;
25     traveller->next = head;
26
27     // to get rid of cycles
28     k = k % listsize;
29     auto cutoffpoint {listsize - k};
30     auto count        {0};
31     auto finalresult   {static_cast<ListNode*>(nullptr)};
32
33     // finding the cutting off point
```

```

34     traveller = head;
35     while(traveller){
36         ++count;                                // appending count
37         if (count == cutoffpoint){
38             finalresult = traveller->next;        // setting up the new head
39             traveller->next = nullptr;           // setting up last pointer
40             break;                               // breaking up
41         }
42         traveller = traveller->next;              // moving to the next point
43     }
44
45     // printing the linked list
46     fPrintLinkedList("final-result = ", finalresult);
47
48     // return
49     return(0);
50
51 }

```

---

## 62. Unique Paths

There is a robot on an  $m \times n$  grid. The robot is initially located at the top-left corner (i.e., `grid[0][0]`). The robot tries to move to the bottom-right corner (i.e., `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  $2 * 10^9$ .

### Examples

#### 1. Example 1:

- Input:  $m = 3, n = 7$
- Output: 28

#### 2. Example 2:

- Input:  $m = 3, n = 2$
- Output: 3

### Constraints

- $1 \leq m, n \leq 100$

### Code

---

```

1  int main(){
2
3      // starting timer
4      Timer timer;
5
6      // input- configuration
7      auto m {3};
8      auto n {7};
9
10     // setup
11     auto row    = [&n](int x){return x/n;};
12     auto col    = [&n](int x){return x%n;};
13     auto tid    {m*n - 1};
14
15     // building dp-table
16     vector<vector<int>> dptable;
17     for(int i = 0; i<m; ++i) {dptable.push_back(vector<int>(n, 0));}
18     dptable[m-1][n-1] = 1;
19
20     // moving through the thing
21     while(tid>=0){
22
23         auto currcol    {col(tid)};
24         auto currow     {row(tid)};
25         auto nummethods {dptable[currow][currcol]};
26
27         if (currcol < n-1) {nummethods += dptable[currow][currcol+1];}
28         if (currow < m-1) {nummethods += dptable[currow+1][currcol];}
29
30         dptable[currow][currcol] = nummethods;
31
32         --tid;
33     }
34

```

```
35 // returning
36 cout << format("final-output = {}\n", dptable[0][0]);
37
38 // return
39 return(0);
40
41 }
```

---

## 63. Unique Paths II

You are given an  $m \times n$  integer array `grid`. There is a robot initially located at the top-left corner (i.e., `grid[0][0]`). The robot tries to move to the bottom-right corner (i.e., `grid[m - 1][n - 1]`). The robot can only move either down or right at any point in time.

An obstacle and space are marked as 1 or 0 respectively in `grid`. A path that the robot takes cannot include any square that is an obstacle.

Return the number of possible unique paths that the robot can take to reach the bottom-right corner.

The testcases are generated so that the answer will be less than or equal to  $2 * 10^9$ .

### Examples

#### 1. Example 1:

- Input: `obstacleGrid = [[0,0,0],[0,1,0],[0,0,0]]`
- Output: 2
- Explanation: There is one obstacle in the middle of the 3x3 grid above.
  - There are two ways to reach the bottom-right corner:
    - 1. Right → Right → Down → Down
    - 2. Down → Down → Right → Right

#### 2. Example 2:

- Input: `obstacleGrid = [[0,1],[0,0]]`
- Output: 1

## Constraints

- $m == \text{obstacleGrid.length}$
- $n == \text{obstacleGrid}[i].\text{length}$
- $1 \leq m, n \leq 100$
- $\text{obstacleGrid}[i][j]$  is 0 or 1.

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     vector<vector<int>> obstacleGrid {
8         {0,0,0},
9         {0,1,0},
10        {0,0,0}
11    };
12
13    // returning zero if the obstacleGrid has a 1 in the end
14    if (obstacleGrid[obstacleGrid.size()-1][obstacleGrid[0].size()-1] == 1) return 0;
15
16    // setup
17    vector<vector<long long>> dptable;
18    for(int i = 0; i<obstacleGrid.size()+1; ++i){
19        dptable.push_back(vector<long long>(obstacleGrid[0].size()+1, 0));
20    }
21}
```



```

22 // writing a one in the destination
23 dptable[obstacleGrid.size()-1][obstacleGrid[0].size()-1] = 1;
24
25 // setting up the copying
26 for(int i = obstacleGrid.size()-1; i>=0; --i){
27     for(int j = obstacleGrid[0].size()-1; j>=0; --j){
28
29         // leaving the paths from this as zero in the case where there is an obstacle.
30         if (obstacleGrid[i][j] == 1) continue;
31
32         // summing up from the right
33         long long currvalue {dptable[i][j] + dptable[i+1][j] + dptable[i][j+1]};
34
35         // writing the sum to the current-value
36         dptable[i][j] = currvalue;
37     }
38 }
39
40 // returning the starting point
41 cout << format("final-output = {}\n", static_cast<int>(dptable[0][0]));
42
43 // return
44 return(0);
45
46 }

```

---

## 64. Minimum Path Sum

Given a  $m \times n$  grid filled with non-negative numbers, find a path from top left to bottom right, which minimizes the sum of all numbers along its path.

Note: You can only move either down or right at any point in time.

### Examples

#### 1. Example 1:

- Input: grid = 

1	3	1
1	5	1
4	2	1
- Output: 7
- Explanation: Because the path  $1 \rightarrow 3 \rightarrow 1 \rightarrow 1 \rightarrow 1$  minimizes the sum.

#### 2. Example 2:

- Input: grid = 

1	2	3
4	5	6
- Output: 12

### Constraints

- $m == \text{grid.length}$

- $n == \text{grid}[i].\text{length}$
- $1 \leq m, n \leq 200$
- $0 \leq \text{grid}[i][j] \leq 200$

## Code

---

```

1  int main(){
2
3      // starting timer
4      Timer timer;
5
6      // input- configuration
7      vector<vector<int>> grid {
8          {1,3,1},
9          {1,5,1},
10         {4,2,1}
11     };
12
13     // setup
14     auto mingrid = grid;
15
16     // going through the values from the bottom right to left
17     for(int i = grid.size()*grid[0].size()-1; i>=0; --i){
18
19         // converting numbers to the row--index and colindex
20         auto rowindex {i/static_cast<int>(grid[0].size())};
21         auto colindex {i%static_cast<int>(grid[0].size())};
22
23         // finding sum of the children with present
24         auto smallestchild {std::numeric_limits<int>::max()};
25

```

```

26 // checking the bottom left
27 if (rowindex == grid.size()-1 && colindex == grid[0].size()-1) {smallestchild = 0; }
28 else if(rowindex == grid.size()-1) {smallestchild = mingrid[rowindex][colindex+1]; }
29 else if (colindex == grid[0].size()-1) {smallestchild = mingrid[rowindex+1][colindex];}
30 else {smallestchild = min(mingrid[rowindex+1][colindex],
31                             mingrid[rowindex][colindex+1]);}
32
33 // storing to the final results
34 mingrid[rowindex][colindex] = mingrid[rowindex][colindex] + smallestchild;
35
36 }
37
38 // returning the smallest value
39 cout << format("final-output = {}\n", mingrid[0][0]);
40
41 // return
42 return(0);
43
44 }

```

---

## 66. Plus One

You are given a large integer represented as an integer array `digits`, where each `digits[i]` is the *i*th digit of the integer. The digits are ordered from most significant to least significant in left-to-right order. The large integer does not contain any leading 0's.

Increment the large integer by one and return the resulting array of digits.

### Examples

#### 1. Example 1:

- Input: `digits = [1,2,3]`
- Output: `[1,2,4]`
- Explanation: The array represents the integer 123.
  - Incrementing by one gives  $123 + 1 = 124$ .
  - Thus, the result should be `[1,2,4]`.

#### 2. Example 2:

- Input: `digits = [4,3,2,1]`
- Output: `[4,3,2,2]`
- Explanation: The array represents the integer 4321.
  - Incrementing by one gives  $4321 + 1 = 4322$ .
  - Thus, the result should be `[4,3,2,2]`.

#### 3. Example 3:

- Input: `digits = [9]`

- Output: [1,0]
- Explanation: The array represents the integer 9.
  - Incrementing by one gives  $9 + 1 = 10$ .
  - Thus, the result should be [1,0].

## Constraints

- $1 \leq \text{digits.length} \leq 100$
- $0 \leq \text{digits}[i] \leq 9$
- digits does not contain any leading 0's.

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto digits {vector<int>{1,2,3}} ;
8
9     // setup
10    auto carry {1};
11    auto sum {-1};
12    vector<int> finalOutput(digits.size()+1, 0);
13
14    // goign through the numbers
15    for(int i = 0; i<digits.size(); ++i){
```

```
16
17 // calculating sum and carry
18 sum    = digits[digits.size()-1-i] + carry;
19 carry  = sum / 10;
20 sum    = sum - carry*10;
21
22 // storing sum and carry
23 finalOutput[finalOutput.size()-1-i] = sum;
24 }
25
26 // in case there is one carry left
27 if (carry != 0) {finalOutput[0] = 1;}
28 else {finalOutput = vector<int>(finalOutput.begin()+1, finalOutput.end());}
29
30 // sending back the finaloutput
31 cout << format("finalOutput = {}\n", finalOutput);
32
33 // return
34 return(0);
35
36 }
```

---

## 67. Add Binary

Given two binary strings *a* and *b*, return their sum as a binary string.

### Examples

1. **Example 1:**

- Input: *a* = "11", *b* = "1"
- Output: "100"

2. **Example 2:**

- Input: *a* = "1010", *b* = "1011"
- Output: "10101"

### Constraints

- $1 \leq a.length, b.length \leq 10^4$
- *a* and *b* consist only of '0' or '1' characters.
- Each string does not contain leading zeros except for the zero itself.



## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto a {string("1010")};
8     auto b {string("1011")};
9
10
11    // setup
12    int carry {0};
13    int a_top {0};
14    int b_top {0};
15    int c_top {0};
16    string finalOutput {};
17
18    // running until the things are empty
19    while(a.size()!=0 || b.size()!=0){
20
21        // copying the carry over tot he sum
22        c_top = carry;
23
24        // shaving off the top
25        if (a.size()){
26            a_top = static_cast<int>(a[a.size()-1] - '0'); // taking the top
27            a = a.substr(0, a.size()-1); // removing the top
28            c_top += a_top; // adding to the sum
29        }
30        if (b.size()){
31            b_top = static_cast<int>(b[b.size()-1] - '0'); // taking the top
32            b = b.substr(0, b.size()-1); // removing the top
33            c_top += b_top; // adding to the sum
```

```

34     }
35
36     // evaluating carry
37     if (c_top == 0)      {carry = 0; c_top = 0;}
38     else if (c_top == 1) {carry = 0; c_top = 1;}
39     else if (c_top == 2) {carry = 1; c_top = 0;}
40     else if (c_top == 3) {carry = 1; c_top = 1;}
41     else                {cout << format("what the actual fuck") << endl;}
42
43     // adding c-TOp to the end of the final output
44     finalOutput = std::string(1,c_top+'0') + finalOutput;
45
46 }
47
48 // check if there is a carry out there
49 if (carry) {finalOutput = std::string(1,carry+'0') + finalOutput;}
50
51 // returnign the final output
52 cout << format("final-output = {}\n", finalOutput);
53
54 // return
55 return(0);
56
57 }

```

---

## 68. Text Justification

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.

Note:

1. A word is defined as a character sequence consisting of non-space characters only.
2. Each word's length is guaranteed to be greater than 0 and not exceed `maxWidth`.
3. The input array `words` contains at least one word.

### Examples

#### 1. Example 1:

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

- "justification. "
- ]

## 2. Example 2:

- Input: words = ["What", "must", "be", "acknowledgment", "shall", "be"], maxWidth = 16
- Output:
  - [
  - "What must be",
  - "acknowledgment ",
  - "shall be "
  - ]
- Explanation: Note that the last line is "shall be " instead of "shall be", because the last line must be left-justified instead of fully-justified. Note that the second line is also left-justified because it contains only one word.

## 3. Example 3:

- Input: words = ["Science", "is", "what", "we", "understand", "well", "enough", "to", "explain", "to", "a", "computer.", "Art", "is", "everything", "else", "we", "do"], maxWidth = 20
- Output:
  - [
  - "Science is what we",
  - "understand well",
  - "enough to explain to",
  - "a computer. Art is",
  - "everything else we",
  - "do "
  - ]

## Constraints

- $1 \leq \text{words.length} \leq 300$
- $1 \leq \text{words}[i].\text{length} \leq 20$
- $\text{words}[i]$  consists of only English letters and symbols.
- $1 \leq \text{maxWidth} \leq 100$
- $\text{words}[i].\text{length} \leq \text{maxWidth}$

## Code

---

```
1 // function to calculate number of non-space characters
2 int fCalcLengthOfTempWithoutSpaces(std::vector<std::string> temp){
3     int num_nonspaces = 0;
4     for(auto x: temp) num_nonspaces += x.size();
5     return num_nonspaces;
6 }
7
8 // function to calculate words formed with temp
9 int fCalcLengthOfTempWithSpaces(std::vector<std::string> temp){
10     int num_nonspaces = 0;
11     for(auto x: temp) num_nonspaces += 1+ x.size();
12     return num_nonspaces-1;
13 }
14
15 // printing temp
16 void fPrintTemp(std::vector<std::string> temp){
17     // printing temp
18     std::cout << "temp = ";
19     for(auto x: temp) std::cout << x << ", ";
```

```

20     std::cout << std::endl;
21 }
22
23 // main-file =====
24 int main(){
25
26     // input- configuration
27     auto words    = vector<string>({"This", "is", "an", "example", "of", "text", "justification."});
28     auto maxWidth {16};
29
30     // setup
31     std::vector<std::string> finalOutput;
32
33     // going through strings
34     int acc = 0;
35     int numwords = 0;
36     int currwidth = 0;
37     std::vector<std::string> temp;
38
39     for(int i = 0; i<words.size(); ++i){
40
41         // updating temp
42         temp.push_back(words[i]);    // updating words in temp
43
44         // checking if width has been crossed
45         if (fCalcLengthOfTempWithSpaces(temp) >= maxWidth || i == words.size()-1){
46
47             // condition temp based on length
48             if(fCalcLengthOfTempWithSpaces(temp)>maxWidth){
49                 temp.pop_back();    // last words gotta go
50                 --i;                // making sure its taken care of in next iteration
51             }
52
53             // finding length of characters in temp
54             int num_nonspaces = fCalcLengthOfTempWithoutSpaces(temp);

```

```

55
56 // finding number of spaces to add
57 int numspacetofill = maxWidth - num_nonspaces;
58
59 // calculating numspots
60 int numspots = temp.size()-1;
61
62 // calculating ideal number of spaces
63 int idealnumspacesperspot;
64 int remainders;
65 if (numspots!=0){
66     idealnumspacesperspot = numspacetofill/numspots;
67     remainders             = numspacetofill%numspots;
68 }
69 else{
70     idealnumspacesperspot = numspacetofill/1;
71     remainders             = numspacetofill%1;
72 }
73
74 // constructing candidate string
75 std::string candidate;
76
77 // adding each word in temp to the candidate
78 for(int j = 0; j < temp.size(); ++j){
79
80     // fetching word
81     auto x = temp[j];
82
83     // adding word to candidate
84     candidate += x;
85
86     // adding spaces
87     if (j!=temp.size()-1)
88         for(int var00 = 0; var00 < idealnumspacesperspot; ++var00)
89             candidate += " ";

```

```

90
91     // checking if there is any remainder left
92     if (remainders > 0){
93         candidate += " ";
94         --remainders;
95     }
96 }
97
98 // checking if there are remaindeers
99 while (remainders > 0){
100     candidate += " ";
101     --remainders;
102 }
103
104 while (candidate.size() != maxWidth) {candidate += " ";}
105
106 // appending candidate to final output
107 finalOutput.push_back(candidate);
108
109 // getting rid of everything
110 if (i != words.size()-1) {temp.clear();}
111 }
112 }
113
114 // making function left justified
115 std::string lastline;
116 for(int i = 0; i < temp.size(); ++i){
117     lastline += temp[i];
118     if (i != temp.size()-1) {lastline += " ";}
119 }
120
121 // adding spaces until end
122 while(lastline.size() != maxWidth) {lastline += " ";}
123
124 // replacing last line

```



```
125     finalOutput[finalOutput.size()-1] = lastline;
126
127     // return
128     return(0);
129
130 }
```

---

## 69. Sqrt(x)

Given a non-negative integer  $x$ , return the square root of  $x$  rounded down to the nearest integer. The returned integer should be non-negative as well.

### Examples

#### 1. Example 1:

- Input:  $x = 4$
- Output: 2
- Explanation: The square root of 4 is 2, so we return 2.

#### 2. Example 2:

- Input:  $x = 8$
- Output: 2
- Explanation: The square root of 8 is 2.82842..., and since we round it down to the nearest integer, 2 is returned.

### Constraints

- $0 \leq x \leq 2^{31} - 1$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto x {8};
8
9     // setup
10    int finaloutput {-1};
11    auto square = [](int x){return x*x;};
12
13    // running
14    for(int i = 0; i<x; ++i){
15        cout << format("{}{},{}\n",square(i),x,square(i+1));
16        if (square(i) <= x && square(i+1)>x) {finaloutput = i; break;}
17    }
18
19    // printing the output
20    cout << format("final-output = {}\n", finaloutput);
21
22    // return
23    return(0);
24
25 }
```

---

## 70. 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?

### Examples

#### 1. 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

#### 2. 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

- $1 \leq n \leq 45$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto n {2};
8
9     // setup
10    std::vector<int> dpTable;
11
12    // number of steps from the last step to the last
13    dpTable.push_back(0);
14    dpTable.push_back(1);
15    dpTable.push_back(2);
16
17    // finding number of ways this can be done
18    for(int i = 2; i<n; ++i){
19        // adding up the last two values
20        dpTable.push_back(dpTable[dpTable.size() - 1] + dpTable[dpTable.size() - 2]);
21    }
22
23    // return the final output
24    cout << format("final-output = {}\n", dpTable[n]);
25
26    // return
27    return(0);
28
29 }
```

---

## 71. Simplify Path

You are given an absolute path for a Unix-style file system, which always begins with a slash '/'. Your task is to transform this absolute path into its simplified canonical path.

The rules of a Unix-style file system are as follows:

- A single period '.' represents the current directory.
- A double period '..' represents the previous/parent directory.
- Multiple consecutive slashes such as '/' and '//' are treated as a single slash '/'.
- Any sequence of periods that does not match the rules above should be treated as a valid directory or file name. For example, '...' and '....' are valid directory or file names.

The simplified canonical path should follow these rules:

- The path must start with a single slash '/'.
- Directories within the path must be separated by exactly one slash '/'.
- The path must not end with a slash '/', unless it is the root directory.
- The path must not have any single or double periods ('.' and '..') used to denote current or parent directories.

Return the simplified canonical path.

## Examples

### 1. Example 1:

- Input: path = `"/home/"`
- Output: `"/home"`
- Explanation: The trailing slash should be removed.

### 2. Example 2:

- Input: path = `"/home//foo/"`
- Output: `"/home/foo"`
- Explanation: Multiple consecutive slashes are replaced by a single one.

### 3. Example 3:

- Input: path = `"/home/user/Documents/../Pictures"`
- Output: `"/home/user/Pictures"`
- Explanation: A double period `".."` refers to the directory up a level (the parent directory).

## Constraints

- $1 \leq \text{path.length} \leq 3000$
- path consists of English letters, digits, period `'.'`, slash `'/'` or `'_'`.
- path is a valid absolute Unix path.

## Code

---

```
1  int main(){
2
3      // starting timer
4      Timer timer;
5
6      // input- configuration
7      string path    {"home/foo/"};
8
9      // setup
10     vector<string> stack;
11
12     // going through the array
13     int i = 0 ;
14     while (i < path.size()){
15
16         // moving until end of string or a /
17         string temp;
18         while(path[i]!='/' && i<path.size()){
19             temp += std::string(1,path[i++]);
20         }
21
22         // continuing if temp size is zero
23         if (temp.size()==0)  {++i; continue;}
24
25         // evaluating the current string
26         if (temp == ".")      {++i; continue;}
27         else if (temp == "..") {
28             if (stack.size()!=0) {stack.pop_back();}
29             ++i;}
30         else {stack.push_back(temp); ++i;}
31     }
32
33 }
```



```
34 // reconstructing final path
35 string finalOutput;
36
37 // reconstructing
38 for(auto x: stack) {finalOutput += "/" + x;}
39
40 // size thing
41 if (finalOutput.size() == 0) {finalOutput += "/";}
42
43 // returning
44 cout << format("finalOutput = {}\n", finalOutput);
45
46 // return
47 return(0);
48
49 }
```

---

## 73. Set Matrix Zeroes

Given an  $m \times n$  integer matrix `matrix`, if an element is 0, set its entire row and column to 0's. You must do it in place.

### Examples

#### 1. Example 1

- Input: `matrix = [[1,1,1],[1,0,1],[1,1,1]]`
- Output: `[[1,0,1],[0,0,0],[1,0,1]]`

#### 2. Example 2

- Input: `matrix = [[0,1,2,0],[3,4,5,2],[1,3,1,5]]`
- Output: `[[0,0,0,0],[0,4,5,0],[0,3,1,0]]`

### Constraints

- $m == \text{matrix.length}$
- $n == \text{matrix}[0].\text{length}$
- $1 \leq m, n \leq 200$
- $-231 \leq \text{matrix}[i][j] \leq 231 - 1$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     vector<vector<int>> matrix{
8         {0,1,2,0},
9         {3,4,5,2},
10        {1,3,1,5}
11    };
12
13    // setup
14    vector<bool> colregister(matrix[0].size(), false); colregister.reserve(colregister.size());
15    vector<bool> rowregister(matrix.size(), false); rowregister.reserve(rowregister.size());
16
17    // registering
18    #pragma omp parallel for
19    for(int i = 0; i<matrix.size(); ++i)
20        for(int j = 0; j<matrix[0].size(); ++j)
21            if (matrix[i][j] == 0) {colregister[j] = true; rowregister[i] = true;}
22
23    // rewriting
24    #pragma omp parallel for
25    for(int i = 0; i<matrix.size(); ++i)
26        for(int j = 0; j<matrix[0].size(); ++j)
27            if (colregister[j] == true || rowregister[i] == true) {matrix[i][j] = 0;}
28
29    // printing the final output
30    cout << format("final-output \n");
31    for(const auto& x: matrix){
32        for(const auto& y: x) {cout << format("{}, ", y);}
33        cout << format("\n");
```

```
34     }  
35  
36     // return  
37     return(0);  
38  
39 }
```

---

## 74. Search a 2D Matrix

You are given an  $m \times n$  integer matrix with the following two properties:

1. Each row is sorted in non-decreasing order.
2. The first integer of each row is greater than the last integer of the previous row.

Given an integer target, return true if target is in matrix or false otherwise.

You must write a solution in  $O(\log(m * n))$  time complexity.

### Examples

#### 1. Example 1

- Input: matrix = `[[1,3,5,7],[10,11,16,20],[23,30,34,60]]`, target = 3
- Output: true

#### 2. Example 2

- Input: matrix = `[[1,3,5,7],[10,11,16,20],[23,30,34,60]]`, target = 13
- Output: false

### Constraints

- `m == matrix.length`

- $n == \text{matrix}[i].\text{length}$
- $1 \leq m, n \leq 100$
- $-10^4 \leq \text{matrix}[i][j], \text{target} \leq 10^4$

## Code

---

```

1 struct Matrix{
2     vector<vector<int>> matrix;
3     int numcols;
4     int numrows;
5     Matrix(vector<vector<int>> matrix0): matrix(matrix0){
6         numcols = matrix0[0].size();
7         numrows = matrix0.size();
8     }
9     int operator()(int row, int col) {return matrix[row][col];}
10    int operator[] (int tid)          {return matrix[tid/numcols][tid%numcols];}
11    int numel()                       {return matrix.size() * matrix[0].size();}
12 };
13
14 int main(){
15
16     // starting timer
17     Timer timer;
18
19     // input- configuration
20     vector<vector<int>> matrix = {
21         {1,3,5,7},
22         {10,11,16,20},
23         {23,30,34,60}};
24     auto target {3};
25

```

```
26 // setup
27 Matrix m(matrix);
28 int left {0};
29 int right {static_cast<int>(matrix.size() * matrix[0].size()) - 1};
30 int mid {-1};
31
32 // binary search
33 while(left <= right){
34     mid = (left + right)/2;
35     if (m[mid] < target) {left = mid+1;}
36     else if (m[mid] > target) {right = mid-1;}
37     else {cout << format("final-output = true\n"); return 0;}
38 }
39
40 // returning false
41 cout << format("final-output = false\n");
42
43 // return
44 return(0);
45
46 }
```

---

## 75. Sort Colors

Given an array `nums` with `n` objects colored red, white, or blue, sort them in-place so that objects of the same color are adjacent, with the colors in the order red, white, and blue.

We will use the integers 0, 1, and 2 to represent the color red, white, and blue, respectively.

You must solve this problem without using the library's sort function.

### Examples

#### 1. Example 1:

- Input: `nums = [2,0,2,1,1,0]`
- Output: `[0,0,1,1,2,2]`

#### 2. Example 2:

- Input: `nums = [2,0,1]`
- Output: `[0,1,2]`

### Constraints

- `n == nums.length`
- $1 \leq n \leq 300$
- `nums[i]` is either 0, 1, or 2.



## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto nums {vector<int>{2,0,2,1,1,0}};
8
9     // setup
10    vector<int> histogram(3, 0); histogram.reserve(histogram.size());
11
12    // moving through inputs
13    for(const auto& x: nums) {++histogram[x];}
14
15    // rewriting
16    auto counter {0};
17    for(int i = 0; i<nums.size(); ++i){
18        while(counter < histogram.size() && histogram[counter] == 0) ++counter;
19        nums[i] = counter; histogram[counter]--;
20    }
21
22    // printing the final-output
23    cout << format("final-output = {}\n", nums);
24
25    // return
26    return(0);
27
28 }
```

---

## 76. Minimum Window Substring

Given two strings  $s$  and  $t$  of lengths  $m$  and  $n$  respectively, return the minimum window substring of  $s$  such that every character in  $t$  (including duplicates) is included in the window. If there is no such substring, return the empty string `""`.

The testcases will be generated such that the answer is unique.

### Examples

#### 1. Example 1:

- Input:  $s = \text{"ADOBECODEBANC"}, t = \text{"ABC"}$
- Output: `"BANC"`
- Explanation: The minimum window substring `"BANC"` includes 'A', 'B', and 'C' from string  $t$ .

#### 2. Example 2:

- Input:  $s = \text{"a"}, t = \text{"a"}$
- Output: `"a"`
- Explanation: The entire string  $s$  is the minimum window.

#### 3. Example 3:

- Input:  $s = \text{"a"}, t = \text{"aa"}$
- Output: `""`
- Explanation: Both 'a's from  $t$  must be included in the window.
  - Since the largest window of  $s$  only has one 'a', return empty string.

## Constraints

- $m == s.length$
- $n == t.length$
- $1 \leq m, n \leq 10^5$
- $s$  and  $t$  consist of uppercase and lowercase English letters.

## Code

---

```
1 // function to convert letter to index
2 int fCharToIndex(char x){
3     if (x >= 65 && x <=90)        {return x - 65;}
4     else if (x >= 97 && x <= 122) {return (x - 97 + (90-65+1));}
5     else                          {std::cerr<<"this shouldn't happen"; return -1;}
6 }
7
8 // compare histograms
9 template<typename T>
10 bool fCompareHist(const vector<T>& t_hist, const vector<T>& runninghist){
11
12     // going throug the list
13     for(int i = 0; i<t_hist.size(); ++i)
14         if (t_hist[i] > runninghist[i])
15             return false;
16
17     // in case all conditions are met
18     return true;
19 }
20 int main(){
21
```

```

22 // starting timer
23 Timer timer;
24
25 // input- configuration
26 auto s {string("ADOBE CODEBANC")};
27 auto t {string("ABC")};
28
29 // setup
30 int p1 {0};
31 int p2 {0};
32 vector<int> finalOutputBoundaries(2, -1);
33 vector<int> t_hist(52, 0); t_hist.reserve(t_hist.size());
34 vector<int> runninghist(52, 0); runninghist.reserve(runninghist.size());
35 auto minlength {std::numeric_limits<int>::max()};
36
37 // setting up t-hist
38 for(const auto x: t) {++t_hist[fCharToIndex(x)];}
39
40 // moving through the string
41 while(p1 <= p2 && p2<s.size()){
42
43     // adding current character
44     if (p2<s.size()) {++runninghist[fCharToIndex(s[p2])];}
45
46     // checking if the two histograms are comparable
47     while(p1<=p2 && fCompareHist(t_hist, runninghist)){
48
49         auto currstringsize {p2-p1+1};
50
51         if (currstringsize>0 && currstringsize < minlength){
52             finalOutputBoundaries = vector<int>({p1, p2});
53             minlength = currstringsize;
54         }
55
56         --runninghist[fCharToIndex(s[p1])];

```

```

57     ++p1;
58 }
59
60 // incrementing p2;
61 ++p2;
62
63 }
64
65 // printing the final output
66 string finalOutput {string(s.begin()+finalOutputBoundaries[0], s.begin() + finalOutputBoundaries[1]+1)};
67
68 // returning
69 if (finalOutputBoundaries[0] == -1 || finalOutputBoundaries[1] == -1) {finalOutput = "";}
70
71 // printing the final-output
72 cout << format("final-output = {}\n", finalOutput);
73
74 // return
75 return(0);
76
77 }

```

---

## 77. Combinations

Given two integers  $n$  and  $k$ , return all possible combinations of  $k$  numbers chosen from the range  $[1, n]$ .

You may return the answer in any order.

### Examples

#### 1. Example 1:

- Input:  $n = 4, k = 2$
- Output:  $[[1,2],[1,3],[1,4],[2,3],[2,4],[3,4]]$
- Explanation: There are 4 choose 2 = 6 total combinations.
  - Note that combinations are unordered, i.e.,  $[1,2]$  and  $[2,1]$  are considered to be the same combination.

#### 2. Example 2:

- Input:  $n = 1, k = 1$
- Output:  $[[1]]$
- Explanation: There is 1 choose 1 = 1 total combination.

### Constraints

- $1 \leq n \leq 20$
- $1 \leq k \leq n$

## Code

---

```
1 void foo(vector<int>          pathsofar,
2         int                  n,
3         int                  k,
4         vector<vector<int>>& finalOutput){
5
6     // checking legnth of pathsofar
7     if (pathsofar.size() > k) return;
8
9     // adding the current path to the final output if the length is k
10    if (pathsofar.size() == k) {finalOutput.push_back(pathsofar); return;}
11
12    // setting up starting point
13    int startingpoint;
14    if (pathsofar.size() == 0) startingpoint = 0+1;
15    else                        startingpoint = pathsofar[pathsofar.size()-1]+1;
16
17    // running through the options
18    for(int i = startingpoint; i<=n; ++i){
19
20        // calling the graph on those
21        auto pathsofar_temp = pathsofar;
22        pathsofar_temp.push_back(i);
23
24        // calling the functiona again
25        foo(pathsofar_temp, n, k, finalOutput);
26    }
27
28    // returning
29    return;
30 }
31
32 int main(){
33
```

```
34 // starting timer
35 Timer timer;
36
37 // input- configuration
38 auto n {4};
39 auto k {2};
40
41 // setup
42 vector< vector<int> > finalOutput;
43 vector<int>          pathsofar;
44
45 // calling the function
46 foo(pathsofar, n, k, finalOutput);
47
48 // printing the output
49 cout << format("finalOutput = {}\n", finalOutput);
50
51 // return
52 return(0);
53
54 }
```

---



## 78. Subsets

Given an integer array `nums` of unique elements, return all possible subsets (the power set).

The solution set must not contain duplicate subsets. Return the solution in any order.

### Examples

1. **Example 1:**

- Input: `nums = [1,2,3]`
- Output: `[[],[1],[2],[1,2],[3],[1,3],[2,3],[1,2,3]]`

2. **Example 2:**

- Input: `nums = [0]`
- Output: `[[],[0]]`

### Constraints

- $1 \leq \text{nums.length} \leq 10$
- $-10 \leq \text{nums}[i] \leq 10$
- All the numbers of `nums` are unique.

## Code

---

```
1 // recursion function
2 void foo(vector<vector<int>>& finalOutput,
3         const vector<int>&   nums,
4         int                 currindex,
5         vector<int>         runningvec,
6         const int&          maxnumelements)
7 {
8     // checking size
9     if (runningvec.size() == maxnumelements) {finalOutput.push_back(runningvec);return;}
10
11    // checking the next set of options
12    for(int i = currindex+1; i < nums.size(); ++i){
13
14        // creating arguments for next call
15        auto runningvec_temp {runningvec};
16        runningvec_temp.push_back(nums[i]);
17        foo(finalOutput, nums, i, runningvec_temp, maxnumelements);
18    }
19
20    // returning
21    return;
22 }
23
24 int main(){
25
26    // starting timer
27    Timer timer;
28
29    // input- configuration
30    auto nums {1,2,3};
31
32    // setup
```

```
34     vector<vector<int>> finalOutput {vector<int>({})};
35
36     // calling the function
37     #pragma omp parallel for
38     for(int i = 1; i<=nums.size(); ++i)
39         foo(finalOutput, nums, -1, vector<int>({}), i);
40
41     // printing the final-output
42     cout << format("finalOutput = {}\n", finalOutput);
43
44     // return
45     return(0);
46
47 }
```

---

## 80. Remove Duplicates from Sorted Array II

Given an integer array `nums` sorted in non-decreasing order, remove some duplicates in-place such that each unique element appears at most twice. The relative order of the elements should be kept the same.

Since it is impossible to change the length of the array in some languages, you must instead have the result be placed in the first part of the array `nums`. More formally, if there are `k` elements after removing the duplicates, then the first `k` elements of `nums` should hold the final result. It does not matter what you leave beyond the first `k` elements.

Return `k` after placing the final result in the first `k` slots of `nums`.

Do not allocate extra space for another array. You must do this by modifying the input array in-place with  $O(1)$  extra memory.

### 1. Example 1

- Input: `nums = [1,1,1,2,2,3]`
- Output: 5, `nums = [1,1,2,2,3,_]`

### 2. Example 2

- Input: `nums = [0,0,1,1,1,1,2,3,3]`
- Output: 7, `nums = [0,0,1,1,2,3,3,_,_]`

## Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> nums {1,1,1,2,2,3};
5 }
```

```

6 // setup
7 int destination {1};
8 int prev        {nums[0]};
9 int element_counter {1};
10 int numwrites    {1};
11
12 // going through the values
13 for(int i = 1; i < nums.size(); ++i){
14
15     // updating counter
16     if (nums[i-1] == nums[i]) {++element_counter;}
17     else                      {element_counter = 1;}
18
19     // checking the element counters
20     if (element_counter <=2) {nums[destination++] = nums[i];}
21
22 }
23
24 // printing the final output
25 cout << format("nums = "); fpv(nums);
26 cout << format("return-value = {}\n", destination);
27
28 // return
29 return(0);
30
31 }

```

---

## Remove Duplicates from Sorted List II

Given the head of a sorted linked list, delete all nodes that have duplicate numbers, leaving only distinct numbers from the original list. Return the linked list sorted as well.

### Examples

1. **Example 1:**

- Input: head = [1,2,3,3,4,5]
- Output: [1,2,5]

2. **Example 2:**

- Input: head = [1,1,1,2,3]
- Output: [2,3]

### Constraints

- The number of nodes in the list is in the range [0, 300].
- $-100 \leq \text{Node.val} \leq 100$
- The list is guaranteed to be sorted in ascending order.

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto head = new ListNode(1);
8     head->next = new ListNode(2);
9     head->next->next = new ListNode(3);
10    head->next->next->next = new ListNode(3);
11    head->next->next->next->next = new ListNode(4);
12    head->next->next->next->next->next = new ListNode(4);
13    head->next->next->next->next->next->next = new ListNode(5);
14
15    // setup
16    auto traveller {head};
17    auto prehead_finaloutput {new ListNode(std::numeric_limits<int>::min())};
18    auto traveller_finaloutput {prehead_finaloutput};
19
20    auto currvalue {-1};
21    auto nextvalue {-1};
22
23    // going through the list
24    while(traveller){
25
26        // checking if current-value is different from top
27        currvalue = traveller->val;
28        nextvalue = traveller->next == nullptr ?
29            std::numeric_limits<int>::min() : traveller->next->val;
30
31        // checking if they're the same
32        if (currvalue == nextvalue){
33            // moving until we find a new-value
```

```
34     while(traveller && traveller->val == currvalue) {traveller = traveller->next;}
35 }
36 else{
37     // pushing current-value
38     traveller_finaloutput->next = traveller;
39     traveller_finaloutput      = traveller_finaloutput->next;
40     traveller                  = traveller->next;
41 }
42 }
43
44 // printing the final-output
45 fPrintLinkedList("final-output = ", prehead_finaloutput->next);
46
47 // return
48 return(0);
49
50 }
```

---



## 86. Partition List

Given the head of a linked list and a value  $x$ , partition it such that all nodes less than  $x$  come before nodes greater than or equal to  $x$ . You should preserve the original relative order of the nodes in each of the two partitions.

### Examples

#### 1. Example 1:

- Input: head = [1,4,3,2,5,2],  $x = 3$
- Output: [1,2,2,4,3,5]

#### 2. Example 2:

- Input: head = [2,1],  $x = 2$
- Output: [1,2]

### Constraints

- The number of nodes in the list is in the range  $[0, 200]$ .
- $-100 \leq \text{Node.val} \leq 100$
- $-200 \leq x \leq 200$

## Code

---

```
1  int main(){
2
3      // starting timer
4      Timer timer;
5
6      // input- configuration
7      auto head {new ListNode(1)};
8      head->next = new ListNode(4);
9      head->next->next = new ListNode(3);
10     head->next->next->next = new ListNode(2);
11     head->next->next->next->next = new ListNode(5);
12     head->next->next->next->next->next = new ListNode(2);
13     auto x {3};
14
15     // setup
16     ListNode* traveller      = head;
17     ListNode* lefthead       = new ListNode(-1);
18     ListNode* lefttraveller  = lefthead;
19     ListNode* righthead      = new ListNode(-1);
20     ListNode* righttraveller = righthead;
21
22     // going through the list
23     while(traveller){
24         // checking next-value
25         if (traveller->val < x){
26             lefttraveller->next = new ListNode(traveller->val);
27             lefttraveller       = lefttraveller->next;
28         }
29         else {
30             righttraveller->next = new ListNode(traveller->val);
31             righttraveller       = righttraveller->next;
32         }
33     }
```

```
34     // moving traveller
35     traveller = traveller->next;
36 }
37
38 // connecting
39 lefttraveller->next = righthead->next;
40
41 // returning
42 fPrintLinkedList("Final-output = ", lefthead->next);
43
44 // return
45 return(0);
46
47 }
```

---

## 88. Merge Sorted Array

You are given two integer arrays `nums1` and `nums2`, sorted in non-decreasing order, and two integers `m` and `n`, representing the number of elements in `nums1` and `nums2` respectively.

Merge `nums1` and `nums2` into a single array sorted in non-decreasing order.

The final sorted array should not be returned by the function, but instead be stored inside the array `nums1`. To accommodate this, `nums1` has a length of `m + n`, where the first `m` elements denote the elements that should be merged, and the last `n` elements are set to 0 and should be ignored. `nums2` has a length of `n`.

### Examples

#### 1. Example 1:

- Input: `nums1 = [1,2,3,0,0,0]`, `m = 3`, `nums2 = [2,5,6]`, `n = 3`
- Output: `[1,2,2,3,5,6]`
- Explanation: The arrays we are merging are `[1,2,3]` and `[2,5,6]`. The result of the merge is `[1,2,2,3,5,6]` with the underlined elements coming from `nums1`.

#### 2. Example 2:

- Input: `nums1 = [1]`, `m = 1`, `nums2 = []`, `n = 0`
- Output: `[1]`
- Explanation: The arrays we are merging are `[1]` and `[]`. The result of the merge is `[1]`.

#### 3. Example 3:

- Input: `nums1 = [0]`, `m = 0`, `nums2 = [1]`, `n = 1`

- Output: [1]
- Explanation: The arrays we are merging are [] and [1]. The result of the merge is [1]. Note that because  $m = 0$ , there are no elements in `nums1`. The 0 is only there to ensure the merge result can fit in `nums1`.

### Constraints:

1. `nums1.length == m + n`
2. `nums2.length == n`
3.  $0 \leq m, n \leq 200$
4.  $1 \leq m + n \leq 200$
5.  $-10^9 \leq \text{nums1}[i], \text{nums2}[j] \leq 10^9$

### Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> nums1 {1, 2, 3, 0, 0, 0};
5     vector<int> nums2 {2, 5, 6};
6     int m   {3};
7     int n   {3};
8
9     // setup
10    int p1   {m-1};
11    int p2   {n-1};
12    int p3   {m+n-1};
```

```

13
14     int curr1  {-1};
15     int curr2  {-1};
16
17     // going the other way
18     while(p1 >= 0 || p2 >= 0)
19     {
20         // printing the values
21         curr1 = p1 >= 0 ? nums1[p1] : std::numeric_limits<int>::min();
22         curr2 = p2 >= 0 ? nums2[p2] : std::numeric_limits<int>::min();
23
24         // assigning value
25         if (curr1 > curr2) {nums1[p3] = curr1; --p3; --p1;}
26         else               {nums1[p3] = curr2; --p3; --p2;}
27
28     }
29
30     // printing the final output
31     cout << format("finaloutput = "); fPrintVector(nums1);
32
33     // return
34     return(0);
35 }

```

---

## 92. Reverse Linked List II

Given the head of a singly linked list and two integers left and right where left  $\leq$  right, reverse the nodes of the list from position left to position right, and return the reversed list.

### Examples

#### 1. Example 1:

- Input: head = [1,2,3,4,5], left = 2, right = 4
- Output: [1,4,3,2,5]

#### 2. Example 2:

- Input: head = [5], left = 1, right = 1
- Output: [5]

### Constraints

- The number of nodes in the list is n.
- $1 \leq n \leq 500$
- $-500 \leq \text{Node.val} \leq 500$
- $1 \leq \text{left} \leq \text{right} \leq n$

## Code

---

```
1  int main(){
2
3      // starting timer
4      Timer timer;
5
6      // input- configuration
7      ListNode* head          = new ListNode(1);
8      head->next               = new ListNode(2);
9      head->next->next          = new ListNode(3);
10     head->next->next->next      = new ListNode(4);
11     head->next->next->next->next = new ListNode(5);
12     auto left {2};
13     auto right {4};
14
15     // trivial case
16     if (left == right) {fPrintLinkedList(head); cout << endl; return 0;}
17
18     // setup
19     ListNode* traveller      = nullptr;
20     ListNode* entrypoint     = nullptr;
21     ListNode* exitpoint     = nullptr;
22     ListNode* revhead        = nullptr;
23     ListNode* dummy          = new ListNode(0);
24     dummy->next               = head;
25
26     // moving through list
27     int nodeposition = -1;
28     traveller = dummy;
29     while(traveller){
30
31         ++nodeposition;    // updating node position
32
33         // finding important points
```



```

34     if(nodeposition == left-1)      {entrypoint = traveller;}
35     else if(nodeposition == left)   {revhead  = traveller;}
36     else if(nodeposition == right+1) {exitpoint = traveller;}
37
38     // moving traveller to next point
39     traveller = traveller->next;
40 }
41
42 // reversing the head
43 ListNode* prev      = nullptr;
44 ListNode* actualright = nullptr;
45 traveller          = revhead;
46 nodeposition        = left;
47
48 while(traveller && nodeposition <= right){
49     ++nodeposition;
50     actualright  = traveller->next; // storing original right
51     traveller->next = prev;        // reconnection
52     prev          = traveller;    // storing prev for next iteration
53     traveller     = actualright;  // moving to original right
54 }
55
56 // tying things together
57 entrypoint->next = prev;
58 revhead->next    = exitpoint;
59
60 // returning dummy-es nstex
61 fPrintLinkedList(dummy->next); cout << endl;
62
63 // return
64 return(0);
65
66 }

```

---

## 94. Binary Tree Inorder Traversal

Given the root of a binary tree, return the inorder traversal of its nodes' values.

### Constraints

- The number of nodes in the tree is in the range [0, 100].
- $-100 \leq \text{Node.val} \leq 100$

### Code

---

```
1 void foo(TreeNode* root,
2     vector<int>& finalOutput)
3 {
4     // sending it back
5     if (root == nullptr) return;
6
7     // sending it left
8     foo(root->left, finalOutput);
9
10    // adding the current-value
11    finalOutput.push_back(root->val);
12
13    // sending it right
14    foo(root->right, finalOutput);
15
16    // sending it back
17    return;
18 }
19
```

```
20 int main(){
21
22     // starting timer
23     Timer timer;
24
25     // input- configuration
26     auto root      {new TreeNode(1)};
27     root->right     = new TreeNode(2);
28     root->right->left = new TreeNode(3);
29
30     // setup
31     vector<int> finalOutput;
32
33     // calling the function
34     foo(root, finalOutput);
35
36     // printing
37     cout << format("final-output = {}\n", finalOutput);
38
39     // return
40     return(0);
41
42 }
```

---

## 97. Interleaving String

Given strings  $s_1$ ,  $s_2$ , and  $s_3$ , find whether  $s_3$  is formed by an interleaving of  $s_1$  and  $s_2$ .

An interleaving of two strings  $s$  and  $t$  is a configuration where  $s$  and  $t$  are divided into  $n$  and  $m$  substrings respectively, such that:

- $s = s_1 + s_2 + \dots + s_n$
- $t = t_1 + t_2 + \dots + t_m$
- $|n - m| \leq 1$
- The interleaving is  $s_1 + t_1 + s_2 + t_2 + s_3 + t_3 + \dots$  or  $t_1 + s_1 + t_2 + s_2 + t_3 + s_3 + \dots$

Note:  $a + b$  is the concatenation of strings  $a$  and  $b$ .

### Examples

#### 1. Example 1:

- Input:  $s_1 = \text{"aabcc"}$ ,  $s_2 = \text{"dbbca"}$ ,  $s_3 = \text{"aadbbcbcac"}$
- Output: true
- Explanation: One way to obtain  $s_3$  is:
  - Split  $s_1$  into  $s_1 = \text{"aa"} + \text{"bc"} + \text{"c"}$ , and  $s_2$  into  $s_2 = \text{"dbbc"} + \text{"a"}$ . Interleaving the two splits, we get  $\text{"aa"} + \text{"dbbc"} +$   
Since  $s_3$  can be obtained by interleaving  $s_1$  and  $s_2$ , we return true.

#### 2. Example 2:

- Input:  $s_1 = \text{"aabcc"}$ ,  $s_2 = \text{"dbbca"}$ ,  $s_3 = \text{"aadbbbacc"}$

- Output: false
- Explanation: Notice how it is impossible to interleave s2 with any other string to obtain s3.

### 3. Example 3:

- Input: s1 = "", s2 = "", s3 = ""
- Output: true

## Constraints

- $0 \leq s1.length, s2.length \leq 100$
- $0 \leq s3.length \leq 200$
- s1, s2, and s3 consist of lowercase English letters.

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto s1    {string("aabcc")};
8     auto s2    {string("dbbca")};
9     auto s3    {string("aadbcbcac")};
10
11     // trivial case
12     if (s1.size() + s2.size() != s3.size()) return static_cast<bool>(0);
```

```

13
14 // setup
15 vector<vector<bool>> dptable;
16
17 // creating dptable
18 for(int i = 0; i<s1.size()+1; ++i) {dptable.push_back(vector<bool>(s2.size()+1, false));}
19
20 // storing a true at the real end of the table
21 dptable[dptable.size()-1][dptable[0].size()-1] = true;
22
23 // moving back from the end
24 for(int i = dptable.size()-1; i>=0; --i){
25     for(int j = dptable[0].size()-1; j>=0; --j){
26
27         // fetching the character at this position
28         auto s2_char {s2[j]};
29         auto s1_char {s1[i]};
30         auto s3_char {s3[i + j]};
31
32         // checking if we can move right
33         if (s1_char == s3_char) {dptable[i][j] = dptable[i][j] + ((i+1) < dptable.size() ? dptable[i+1][j] : 0);}
34
35         // checking if we can move down
36         if (s2_char == s3_char) {dptable[i][j] = dptable[i][j] + ((j+1) < dptable[0].size() ? dptable[i][j+1] : 0);}
37
38     }
39 }
40
41 // returning the first value
42 cout << format("final-output = {}\n", dptable[0][0]);
43
44 // return
45 return(0);
46
47 }

```

## 98. Validate Binary Search Tree

Given the root of a binary tree, determine if it is a valid binary search tree (BST).

A valid BST is defined as follows:

- The left subtree of a node contains only nodes with keys strictly less than the node's key.
- The right subtree of a node contains only nodes with keys strictly greater than the node's key.
- Both the left and right subtrees must also be binary search trees.

### Constraints

- The number of nodes in the tree is in the range  $[1, 104]$ .
- $-2^{31} \leq \text{Node.val} \leq 2^{31} - 1$

### Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto root    {new TreeNode(2)};
8     root->left    = new TreeNode(1);
9     root->right   = new TreeNode(3);
10
```

```

11 // setup
12 bool validBSTFlag = true;
13 vector<int> nodevalues;
14
15 std::function<void(const TreeNode*)> foo = [&foo, &nodevalues, &validBSTFlag](
16     const TreeNode* root){
17
18     // if false, stop everything
19     if (validBSTFlag == false) {return;}
20
21     // returning
22     if (root == nullptr) {return;}
23
24     // going left
25     if (root->left) {foo(root->left);}
26
27     // adding current
28     if (nodevalues.size() == 0) {nodevalues.push_back(root->val);}
29     else{
30         // check top
31         auto topvalue = nodevalues[nodevalues.size()-1];
32
33         // check if top value is less than or equal
34         if (topvalue >= root->val) {validBSTFlag = false;} // since this is not valid
35         else {nodevalues.push_back(root->val);}
36     }
37
38     // going right
39     if (root->right) {foo(root->right);}
40 };
41
42 // calling function
43 foo(root);
44
45 // returning

```



```
46     cout << format("final-output = {}\n", validBSTFlag);
47
48     // return
49     return(0);
50 }
```

---

## 99. Recover Binary Search Tree

You are given the root of a binary search tree (BST), where the values of exactly two nodes of the tree were swapped by mistake. Recover the tree without changing its structure.

### Examples

#### 1. Example 1:

- Input: root = [1,3,null,null,2]
- Output: [3,1,null,null,2]
- Explanation: 3 cannot be a left child of 1 because 3 > 1. Swapping 1 and 3 makes the BST valid.

#### 2. Example 2:

- Input: root = [3,1,4,null,null,2]
- Output: [2,1,4,null,null,3]
- Explanation: 2 cannot be in the right subtree of 3 because 2 < 3. Swapping 2 and 3 makes the BST valid.

### Constraints

- The number of nodes in the tree is in the range [2, 1000].
- $-2^{31} \leq \text{Node.val} \leq 2^{31} - 1$

## Code

---

```
1 // the function
2 void foo(TreeNode*          root,
3     vector<TreeNode*>&      nodeaddresses,
4     vector<int>&           nodevalues){
5
6     // sending it back
7     if (root == nullptr) return;
8
9     // going through the left
10    foo(root->left, nodeaddresses, nodevalues);
11
12    // adding the current
13    nodeaddresses.push_back( root);
14    nodevalues.push_back(    root->val);
15
16    // going right
17    foo(root->right, nodeaddresses, nodevalues);
18
19    // returning
20    return;
21 }
22
23 int main(){
24
25     // starting timer
26     Timer timer;
27
28     // input- configuration
29     auto root    {new TreeNode(1)};
30     root->left    = new TreeNode(3);
31     root->left->right = new TreeNode(2);
32
33     // setup
```

```
34     vector<TreeNode*> nodeaddresses;
35     vector<int>         nodevalues;
36
37     // calling the function
38     foo(root, nodeaddresses, nodevalues);
39
40     // sort the values and assign it
41     std::sort(nodevalues.begin(), nodevalues.end());
42
43     // writing the values as is
44     #pragma omp
45     for(int i = 0; i<nodeaddresses.size(); ++i){
46         nodeaddresses[i]->val = nodevalues[i];
47     }
48
49     // return
50     return(0);
51
52 }
```

---

## 100. Same Tree

Given the roots of two binary trees *p* and *q*, write a function to check if they are the same or not.

Two binary trees are considered the same if they are structurally identical, and the nodes have the same value.

### Examples

#### 1. Example 1:

- Input: *p* = [1,2,3], *q* = [1,2,3]
- Output: true

#### 2. Example 2:

- Input: *p* = [1,2], *q* = [1,null,2]
- Output: false

#### 3. Example 3:

- Input: *p* = [1,2,1], *q* = [1,1,2]
- Output: false

### Constraints

- The number of nodes in both trees is in the range [0, 100].
- $-10^4 \leq \text{Node.val} \leq 10^4$

## Code

---

```
1  int main(){
2
3      // starting timer
4      Timer timer;
5
6      // input- configuration
7      auto p {new TreeNode(1)};
8      p->left   = new TreeNode(2);
9      p->right  = new TreeNode(3);
10
11     auto q {new TreeNode(1)};
12     q->left   = new TreeNode(2);
13     q->right  = new TreeNode(3);
14
15     // setup
16     std::function<bool(TreeNode*, TreeNode*)> fCompareTrees = [&fCompareTrees](
17         TreeNode* p, TreeNode* q){
18
19         // basecase
20         if (p == nullptr && q == nullptr)    return true;
21         if (p == nullptr && q != nullptr)    return false;
22         if (p != nullptr && q == nullptr)    return false;
23         if (p->val != q->val)                  return false;
24
25         // going through the next set of branches
26         return (fCompareTrees(p->left, q->left) && fCompareTrees(p->right, q->right));
27     };
28
29     // going through the two nodes
30     bool finalOutput = fCompareTrees(p, q);
31
32     // returning final output
33     cout << format("final-output = {}\n", finalOutput);
```

```
34
35 // return
36 return(0);
37
38 }
```

---

## 101. Symmetric Tree

Given the root of a binary tree, check whether it is a mirror of itself (i.e., symmetric around its center).

### Examples

#### 1. Example 1:

- Input: root = [1,2,2,3,4,4,3]
- Output: true

#### 2. Example 2:

- Input: root = [1,2,2,null,3,null,3]
- Output: false

### Constraints

- The number of nodes in the tree is in the range [1, 1000].
- $-100 \leq \text{Node.val} \leq 100$

### Code



---

```

1  int main(){
2
3      // starting timer
4      Timer timer;
5
6      // input- configuration
7      auto root      {new TreeNode(1)};
8      root->left      = new TreeNode(2);
9      root->right      = new TreeNode(2);
10     root->left->left  = new TreeNode(3);
11     root->left->right = new TreeNode(4);
12     root->right->left = new TreeNode(4);
13     root->right->right = new TreeNode(3);
14
15     // setup
16     std::function<bool(TreeNode*, TreeNode*)> dfs = [&dfs](
17         TreeNode* leftNode,
18         TreeNode* rightNode){
19
20         // printing the base-cases
21         if (leftNode == nullptr && rightNode == nullptr) return true;
22         if (leftNode == nullptr || rightNode == nullptr) return false;
23
24         // calling the children
25         bool finaloutput = (leftNode->val == rightNode->val)    && \
26                             dfs(leftNode->left, rightNode->right) && \
27                             dfs(leftNode->right, rightNode->left);
28
29         // returning the value
30         return finaloutput;
31     };
32
33     // running
34     cout << format("final-output = {}\n", dfs(root->left, root->right));

```

```
35
36 // return
37 return(0);
38 }
```

---

## 102. Binary Tree Level Order Traversal

Given the root of a binary tree, return the level order traversal of its nodes' values. (i.e., from left to right, level by level).

### Constraints

- The number of nodes in the tree is in the range [0, 2000].
- $-1000 \leq \text{Node.val} \leq 1000$

### Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto root      {new TreeNode(3)};
8     root->left      = new TreeNode(9);
9     root->right      = new TreeNode(20);
10    root->right->left  = new TreeNode(15);
11    root->right->right = new TreeNode(7);
12
13    // setup
14    std::vector< std::vector<int> > finalOutput;
15    std::function<void(const TreeNode*, int)> f = [&f, &finalOutput](
16        const TreeNode* root,
17        int level){
18
19        // base-case
```

```

20     if (root == nullptr) return;
21
22     // finding current-level
23     level += 1;
24
25     // increasing size of the thing
26     while (finalOutput.size() < level+1)
27         finalOutput.push_back(std::vector<int>());
28
29     // appending to value
30     if (finalOutput.size() < level+1)
31         finalOutput[level] = std::vector<int>(root->val);
32     else
33         finalOutput[level].push_back(root->val);
34
35     // calling
36     f(root->left, level);
37     f(root->right, level);
38
39     // returning return;
40     return;
41
42 };
43
44 // going through the tree
45 f(root, -1);
46
47 // printing the final output
48 cout << format("finalOutput = {}\n", finalOutput);
49
50 // return
51 return(0);
52
53 }

```

---

## 103. Binary Tree Zigzag Level Order Traversal

Given the root of a binary tree, return the zigzag level order traversal of its nodes' values. (i.e., from left to right, then right to left for the next level and alternate between).

### Examples

#### 1. Example 1:

- Input: root = [3,9,20,null,null,15,7]
- Output: [[3],[20,9],[15,7]]

#### 2. Example 2:

- Input: root = [1]
- Output: [[1]]

#### 3. Example 3:

- Input: root = []
- Output: []

### Constraints

- The number of nodes in the tree is in the range [0, 2000].
- $-100 \leq \text{Node.val} \leq 100$

## Code

---

```
1 void f(TreeNode* root,
2     std::vector< std::vector<int> >& finalOutput,
3     int level)
4 {
5
6     // base-case
7     if (root == nullptr) return;
8
9     // finding current-level
10    level += 1;
11
12    // increasing size of the thing
13    while (finalOutput.size() < level+1) {finalOutput.push_back(std::vector<int>());}
14
15    // appending to value
16    if (finalOutput.size() < level+1 ) {finalOutput[level] = std::vector<int>(root->val);}
17    else{
18        // appending based on level
19        if (level%2 == 0)
20            finalOutput[level].push_back(root->val);
21        else
22        {
23            std::vector<int> temp {root->val};
24            for(auto x: finalOutput[level]) {temp.push_back(x);}
25            finalOutput[level] = temp;
26        }
27    }
28
29    // calling
30    f(root->left, finalOutput, level);
31    f(root->right, finalOutput, level);
32
33    // returning return;
```

```

34     return;
35 }
36 int main(){
37
38     // starting timer
39     Timer timer;
40
41     // input- configuration
42     auto root      {new TreeNode(3)};
43     root->left      = new TreeNode(9);
44     root->right      = new TreeNode(20);
45     root->right->left = new TreeNode(15);
46     root->right->right = new TreeNode(7);
47
48     // setup
49     std::vector< std::vector<int> > finalOutput;
50
51     // going through the tree
52     f(root, finalOutput, -1);
53
54     // sending back final output
55     cout << format("final-output = {}\n", finalOutput);
56
57     // return
58     return(0);
59 }
60

```

---

## 104. Maximum Depth of Binary Tree

Given the root of a binary tree, return its maximum depth.

A binary tree's maximum depth is the number of nodes along the longest path from the root node down to the farthest leaf node.

### Examples

#### 1. Example 1:

- Input: root = [3,9,20,null,null,15,7]
- Output: 3

#### 2. Example 2:

- Input: root = [1,null,2]
- Output: 2

### Constraints

- The number of nodes in the tree is in the range  $[0, 10^4]$ .
- $-100 \leq \text{Node.val} \leq 100$

### Code



---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto root      {new TreeNode(3)};
8     root->left      = new TreeNode(9);
9     root->right     = new TreeNode(20);
10    root->right->left = new TreeNode(15);
11    root->right->right = new TreeNode(7);
12
13    // setup
14    auto maxcount {0};
15    auto count    {0};
16
17    // lambda - function
18    std::function<void(const TreeNode*, int)> fTraverse = [&fTraverse,
19                                                         &maxcount](
20        const TreeNode* root,
21        int count){
22
23        // checking if null
24        if (root == nullptr) return;
25
26        ++count;                                // updating length
27        maxcount = max(maxcount, count);         // checking maxlength
28
29        fTraverse(root->left, count);             // checking if we can go left
30        fTraverse(root->right, count);           // checking if we can go right
31
32        // returning
33        return;
34    };
```

```
35
36 // calling the function
37 fTraverse(root, count);
38
39 // returning
40 cout << format("final-output = {}\n", maxcount);
41
42 // return
43 return(0);
44
45 }
```

---

## 105. Construct Binary Tree from Preorder and Inorder Traversal

Given two integer arrays preorder and inorder where preorder is the preorder traversal of a binary tree and inorder is the inorder traversal of the same tree, construct and return the binary tree.

### Examples

#### 1. Example 1:

- Input: preorder = [3,9,20,15,7], inorder = [9,3,15,20,7]
- Output: [3,9,20,null,null,15,7]

#### 2. Example 2:

- Input: preorder = [-1], inorder = [-1]
- Output: [-1]

### Constraints

- $1 \leq \text{preorder.length} \leq 3000$
- $\text{inorder.length} == \text{preorder.length}$
- $-3000 \leq \text{preorder}[i], \text{inorder}[i] \leq 3000$
- preorder and inorder consist of unique values.
- Each value of inorder also appears in preorder.

- preorder is guaranteed to be the preorder traversal of the tree.
- inorder is guaranteed to be the inorder traversal of the tree.

## Code

---

```
1  TreeNode* foo(vector<int> preorder, vector<int> inorder)
2  {
3
4      // returning for trivial case
5      if (preorder.size() == 0 || inorder.size() == 0) {return static_cast<TreeNode*>(nullptr);}
6
7      // setup
8      auto& rootvalue    {preorder[0]};
9      auto root          {new TreeNode(preorder[0])};
10
11     // sending it back for trivial case
12     if (preorder.size() == 1 && inorder.size() == 1) {return root;}
13
14     // finding root-position
15     auto rootposition = std::find(inorder.begin(),
16                                   inorder.end(),
17                                   rootvalue);
18
19     // creating left-subtree
20     auto leftinorder {vector<int>(inorder.begin(), rootposition)};
21     auto rightinorder {vector<int>(rootposition+1, inorder.end())};
22
23     // creating subset of preorder
24     auto leftpreorder {vector<int>(preorder.begin()+1,
25                                     preorder.begin() + leftinorder.size() + 1)};
26     auto rightpreorder {vector<int>(preorder.begin() + leftinorder.size()+1,
27                                     preorder.end())};
```

```
28
29 // calling the function on left and right
30 root->left    = foo(leftpreorder, leftinorder);
31 root->right   = foo(rightpreorder, rightinorder);
32
33 // returning the
34 return root;
35
36 }
37 int main(){
38
39 // starting timer
40 Timer timer;
41
42 // input- configuration
43 auto preorder {vector<int>{3,9,20,15,7}};
44 auto inorder  {vector<int>{9,3,15,20,7}};
45
46 // manually building the tree
47 auto root {foo(preorder, inorder)};
48
49 // return
50 return(0);
51
52 }
```

---

## 107. Binary Tree Level Order Traversal II

Given the root of a binary tree, return the bottom-up level order traversal of its nodes' values. (i.e., from left to right, level by level from leaf to root).

### Examples

1. **Example 1:**

- Input: root = [3,9,20,null,null,15,7]
- Output: [[15,7],[9,20],[3]]

2. **Example 2:**

- Input: root = [1]
- Output: [[1]]

3. **Example 3:**

- Input: root = []
- Output: []

### Constraints

- The number of nodes in the tree is in the range [0, 2000].
- $-1000 \leq \text{Node.val} \leq 1000$

## Code

---

```
1 void foo(TreeNode* root,
2     map<int, vector<int>, std::greater<int>>& levelToMembers,
3     int currlevel){
4
5     // sending it back
6     if (root==nullptr) return;
7
8     // incrementing currlevel
9     ++currlevel;
10
11    // moving left
12    foo(root->left, levelToMembers, currlevel);
13
14    // checking if the current-level is present
15    if (levelToMembers.find(currlevel) == levelToMembers.end())
16        levelToMembers[currlevel] = vector<int>({root->val});
17    else
18        levelToMembers[currlevel].push_back(root->val);
19
20    // moving right
21    foo(root->right, levelToMembers, currlevel);
22
23    // returning
24    return;
25 }
26
27 int main(){
28
29     // starting timer
30     Timer timer;
31
32     // input- configuration
33     auto root {new TreeNode()};
```

```

34 root->left      = new TreeNode(9);
35 root->right     = new TreeNode(20);
36 root->right->left = new TreeNode(15);
37 root->right->right = new TreeNode(7);
38
39 // setup
40 map<int, vector<int>, std::greater<int>> levelToMembers;
41 vector<vector<int>> finalOutput;
42
43 // running the function
44 foo(root, levelToMembers, -1);
45
46 // printing the values
47 #pragma omp parallel for
48 for(auto x: levelToMembers) {finalOutput.push_back(x.second);}
49
50 // returning the final output
51 cout << format("final-output = {}\n", finalOutput);
52
53 // return
54 return(0);
55
56 }

```

---



## 108. Convert Sorted Array to Binary Search Tree

Given an integer array `nums` where the elements are sorted in ascending order, convert it to a height-balanced binary search tree.

### Constraints

- $1 \leq \text{nums.length} \leq 10^4$
- $-10^4 \leq \text{nums}[i] \leq 10^4$
- `nums` is sorted in a strictly increasing order.

### Code

---

```
1 void foo(TreeNode*      parent,
2     int                parentdirection,
3     vector<int>&        nums,
4     int                left,
5     int                right)
6 {
7     // sending it back if right is less than left
8     if (left > right) return;
9
10    // finding mid point
11    int mid = (left + right)/2;
12
13    // creating mid-node
14    TreeNode* midnode = new TreeNode(nums[mid]);
15
16    // connecting current to parent node
```

```

17     if (parentdirection == -1)        {parent->right = midnode;}
18     else if (parentdirection == 1)    {parent->left  = midnode;}
19
20     // going left
21     foo(midnode, 1, nums, left, mid-1);
22
23     // going right
24     foo(midnode, -1, nums, mid+1, right);
25
26     // returning
27     return;
28
29 }
30 int main(){
31
32     // starting timer
33     Timer timer;
34
35     // input- configuration
36     vector<int> nums  {-10,-3,0,5,9};
37
38     // setup
39     TreeNode* dummy = new TreeNode(-1);
40
41     // calling the function
42     foo(dummy, -1, nums, 0, nums.size()-1);
43
44     // return
45     return(0);
46
47 }

```

---

## 109. Convert Sorted List to Binary Search Tree

Given the head of a singly linked list where elements are sorted in ascending order, convert it to a height-balanced binary search tree.

### Constraints

- The number of nodes in head is in the range  $[0, 2 * 10^4]$ .
- $-105 \leq \text{Node.val} \leq 105$

### Code

---

```
1 void foo(TreeNode*      parent,
2     int                parentdirection,
3     vector<int>&        nums,
4     int                left,
5     int                right)
6 {
7     // sending it back if right is less than left
8     if (left > right) return;
9
10    // finding mid point
11    int mid = (left + right)/2;
12
13    // creating mid-node
14    TreeNode* midnode = new TreeNode(nums[mid]);
15
16    // connecting current to parent node
17    if (parentdirection == -1) parent->right = midnode;
18    else if (parentdirection == 1) parent->left = midnode;
19
```

```

20 // going left
21 foo(midnode, 1, nums, left, mid-1);
22
23 // going right
24 foo(midnode, -1, nums, mid+1, right);
25
26 // returning
27 return;
28
29 }
30
31 int main(){
32
33 // starting timer
34 Timer timer;
35
36 // input- configuration
37 auto head {new ListNode(-10)};
38 head->next = new ListNode(-3);
39 head->next->next = new ListNode(0);
40 head->next->next->next = new ListNode(5);
41 head->next->next->next->next = new ListNode(9);
42
43 // sending it back if the list is empty
44 if (head == nullptr) {cout << format("final-output = \n");}
45
46 // making a vector out of the whole list
47 auto traveller = head;
48 vector<int> nums;
49 while(traveller){
50     nums.push_back(traveller->val);
51     traveller = traveller->next;
52 }
53
54 // calling the previous function into this

```

```
55     TreeNode* dummy = new TreeNode(-1);
56
57     // calling the function
58     foo(dummy, -1, nums, 0, nums.size()-1);
59
60     // return
61     return(0);
62
63 }
```

---

## 112. Path Sum

Given the root of a binary tree and an integer targetSum, return true if the tree has a root-to-leaf path such that adding up all the values along the path equals targetSum.

### Constraints

- The number of nodes in the tree is in the range [0, 5000].
- $-1000 \leq \text{Node.val} \leq 1000$
- $-1000 \leq \text{targetSum} \leq 1000$

### Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto root      {new TreeNode(5)};
8
9     root->left      = new TreeNode(4);
10    root->right      = new TreeNode(8);
11
12    root->left->left   = new TreeNode(11);
13    root->right->left  = new TreeNode(13);
14    root->right->right = new TreeNode(4);
15
```

```

16 root->left->left->left    = new TreeNode(7);
17 root->left->left->right   = new TreeNode(2);
18 root->right->right->right = new TreeNode(1);
19
20 auto targetSum    {22};
21
22 // setup
23 auto runningsum   {0};
24 auto binaryflag   {false};
25 std::function<void(const TreeNode*, int)> fRunSum = [&fRunSum,
26                                     &targetSum,
27                                     &binaryflag](
28     const TreeNode* root,
29     int runningsum
30 ){
31
32     // sending it back
33     if (root == nullptr) return;
34     if (binaryflag == true) return;
35
36     // adding current val to running sum
37     runningsum += root->val;
38
39     // checking if there are children
40     if (root->left || root->right){
41         if (root->left) fRunSum(root->left, runningsum);
42         if (root->right) fRunSum(root->right, runningsum);
43     }
44     else{
45         // in this case, we check the running sum
46         if (runningsum == targetSum){ binaryflag = true;}
47     }
48
49     // returning
50     return;

```

```
51     };
52
53     // running
54     fRunSum(root, runningsum);
55
56     // printing
57     cout << format("final-output = {}\n", binaryflag);
58
59     // return
60     return(0);
61
62 }
```

---



## 114. Flatten Binary Tree to Linked List

Given the root of a binary tree, flatten the tree into a “linked list”:

- The “linked list” should use the same `TreeNode` class where the right child pointer points to the next node in the list and the left child pointer is always null.
- The “linked list” should be in the same order as a pre-order traversal of the binary tree.

### Examples

#### 1. Example 1:

- Input: root = [1,2,5,3,4,null,6]
- Output: [1,null,2,null,3,null,4,null,5,null,6]

#### 2. Example 2:

- Input: root = []
- Output: []

#### 3. Example 3:

- Input: root = [0]
- Output: [0]

## Constraints

- The number of nodes in the tree is in the range [0, 2000].
- $-100 \leq \text{Node.val} \leq 100$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto root      {new TreeNode(1)};
8     root->left      = new TreeNode(2);
9     root->right     = new TreeNode(5);
10    root->left->left  = new TreeNode(3);
11    root->left->right = new TreeNode(4);
12    root->right->right = new TreeNode(6);
13
14    // recursion lambda
15    auto foo = [&foo](TreeNode*      root,
16                vector<TreeNode*>& nodeaddresses){
17
18        // sending it back
19        if (root == nullptr) return;
20
21        // adding address
22        nodeaddresses.push_back(root);
23
24        // going down left
25        if (root->left) foo(root->left, nodeaddresses);
```

```

26     if (root->right) foo(root->right, nodeaddresses);
27
28     // returning
29     return;
30 };
31
32 // trivial case
33 if (root == nullptr) return 0;
34
35 // setup
36 vector<TreeNode*> nodeaddresses;
37
38 // fill registers
39 foo(root, nodeaddresses);
40
41 // going through the addresses and reconnecting it
42 for(int i = 0; i<nodeaddresses.size()-1; ++i){
43     nodeaddresses[i]->left = nullptr;
44     nodeaddresses[i]->right = nodeaddresses[i+1];
45 }
46
47 // taking care of the last
48 nodeaddresses[nodeaddresses.size()-1]->left = nullptr;
49 nodeaddresses[nodeaddresses.size()-1]->right = nullptr;
50
51 // return
52 return(0);
53
54 }

```

---

## 116. Populating Next Right Pointers in Each Node

You are given a perfect binary tree where all leaves are on the same level, and every parent has two children. The binary tree has the following definition:

---

```
1 struct Node {  
2     int val;  
3     Node *left;  
4     Node *right;  
5     Node *next;  
6 }
```

---

Populate each next pointer to point to its next right node. If there is no next right node, the next pointer should be set to NULL.

Initially, all next pointers are set to NULL.

### Constraints

- The number of nodes in the tree is in the range  $[0, 2^{12} - 1]$ .
- $-1000 \leq \text{Node.val} \leq 1000$

### Code

---

```
1 // Definition for a Node.  
2 class Node {  
3 public:  
4     int val;  
5     Node* left;
```

```

6     Node* right;
7     Node* next;
8
9     Node() : val(0), left(NULL), right(NULL), next(NULL) {}
10
11    Node(int _val) : val(_val), left(NULL), right(NULL), next(NULL) {}
12
13    Node(int _val, Node* _left, Node* _right, Node* _next)
14        : val(_val), left(_left), right(_right), next(_next) {}
15 };
16
17 void foo(deque<Node*> parents)
18 {
19     // sendint it back if empty
20     if (parents.size() < 1) {return;}
21
22     // adding a nullptr to the parents list as demarcater
23     parents.push_back(static_cast<Node*>(nullptr));
24
25     // adding children to parents list until we hit the nullptr
26     while(parents[1] != static_cast<Node*>(nullptr)){
27
28         // connecting the top
29         parents[0]->next = parents[1];
30
31         // adding the children to the pipeline
32         if(parents[0]->left) {parents.push_back(parents[0]->left);}
33         if(parents[0]->right) {parents.push_back(parents[0]->right);}
34
35         // popping the top
36         parents.pop_front();
37     }
38
39     // adding the children to the pipeline
40     if(parents[0]->left) {parents.push_back(parents[0]->left);}

```

```

41     if(parents[0]->right) {parents.push_back(parents[0]->right);}
42
43     // popping the top two parents
44     parents.pop_front();
45     parents.pop_front();
46
47     // calling the function again
48     foo(parents);
49
50     // returning
51     return;
52 }
53
54 int main(){
55
56     // starting timer
57     Timer timer;
58
59     // input- configuration
60     auto root          {new Node(1)};
61     root->left          = new Node(2);
62     root->right         = new Node(3);
63     root->left->left     = new Node(4);
64     root->left->right    = new Node(5);
65     root->right->left    = new Node(6);
66     root->right->right   = new Node(7);
67
68     // trivial case
69     if (root == nullptr) {return 0;}
70
71     // setup
72     deque<Node*> parents {root};
73
74     // calling the function
75     foo(parents);

```

```
76
77     // return
78     return(0);
79
80 }
```

---

## 117. Populating Next Right Pointers in Each Node II

Given a binary tree of type

---

```
1 struct Node {  
2     int val;  
3     Node *left;  
4     Node *right;  
5     Node *next;  
6 }
```

---

Populate each next pointer to point to its next right node. If there is no next right node, the next pointer should be set to NULL. Initially, all next pointers are set to NULL.

### Examples

#### 1. Example 1:

- Input: root = [1,2,3,4,5,null,7]
- Output: [1,#,2,3,#,4,5,7,#]
- Explanation: Given the above binary tree (Figure A), your function should populate each next pointer to point to its next right node, just like in Figure B. The serialized output is in level order as connected by the next pointers, with # signifying the end of each level.

#### 2. Example 2:

- Input: root = []
- Output: []



## Constraints

- The number of nodes in the tree is in the range [0, 6000].
- $-100 \leq \text{Node.val} \leq 100$

## Code

---

```
1  class Node {
2  public:
3      int val;
4      Node* left;
5      Node* right;
6      Node* next;
7
8      Node() : val(0), left(NULL), right(NULL), next(NULL) {}
9      Node(int _val) : val(_val), left(NULL), right(NULL), next(NULL) {}
10     Node(int _val, Node* _left, Node* _right, Node* _next)
11         : val(_val), left(_left), right(_right), next(_next) {}
12 };
13
14
15 int main(){
16
17     // starting timer
18     Timer timer;
19
20     // input- configuration
21     auto root    {new Node(1)};
22     root->left    = new Node(2);
23     root->right   = new Node(3);
24     root->left->left = new Node(4);
25     root->left->right = new Node(5);
```

```

26 root->right->right = new Node(7);
27
28 // running
29 if (root == nullptr) {cout << format("done!\n"); return 0;}
30
31 // calling the function
32 int count = -1;
33 vector< vector<Node*> > addressvectors;
34
35 // calling the function
36 foo(root, count, addressvectors);
37
38 // building the connections
39 for(auto x: addressvectors){
40     int i = 0;
41     for(; i<x.size()-1; ++i)
42         if (x[i] != nullptr) {x[i]->next = x[i+1];}           // look to the right
43
44     // ensuring that the last pointer points to the right most
45     x[i]->next = nullptr;
46 }
47
48 // completion
49 cout << format("done!\n");
50
51 // return
52 return(0);
53
54 }

```

---

## 120. Triangle

Given a triangle array, return the minimum path sum from top to bottom.

For each step, you may move to an adjacent number of the row below. More formally, if you are on index  $i$  on the current row, you may move to either index  $i$  or index  $i + 1$  on the next row.

### Examples

#### 1. Example 1:

- Input: `triangle = [[2],[3,4],[6,5,7],[4,1,8,3]]`
- Output: 11
- Explanation: The triangle looks like:
  - The minimum path sum from top to bottom is  $2 + 3 + 5 + 1 = 11$  (underlined above).

#### 2. Example 2:

- Input: `triangle = [[-10]]`
- Output: -10

### Constraints

- $1 \leq \text{triangle.length} \leq 200$
- `triangle[0].length == 1`
- `triangle[i].length == triangle[i - 1].length + 1`

- $-10^4 \leq \text{triangle}[i][j] \leq 10^4$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     vector<vector<int>> triangle = {
8         {2},
9         {3,4},
10        {6,5,7},
11        {4,1,8,3}
12    };
13
14    // setup - input
15    vector<int> row = triangle[triangle.size()-1];
16
17    // filling up the values
18    for(int i = triangle.size()-2; i>=0; --i){
19
20        // going through the rows
21        for(int j = 0; j<=i; ++j){
22
23            auto currentvalue {triangle[i][j]};           // fetching current value
24            auto smallerchild {std::min(row[j], row[j+1])}; // finding the smaller of the two children
25            row[j] = currentvalue + smallerchild;         // adding to the parent and storing to the new array
26
27        }
28    }
29}
```

```
30 // printign the final output
31 cout << format("final-output = {}\n", row[0]);
32
33 // return
34 return(0);
35
36 }
```

---

## 121. Best Time To Buy And Sell Stock

You are given an array `prices` where `prices[i]` is the price of a given stock on the *i*th day. You want to maximize your profit by choosing a single day to buy one stock and choosing a different day in the future to sell that stock. Return the maximum profit you can achieve from this transaction. If you cannot achieve any profit, return 0.

### Examples

#### 1. Example 1

- Input: `prices = [7,1,5,3,6,4]`
- Output: 5

#### 2. Example 2

- Input: `prices = [7,6,4,3,1]`
- Output: 0

### Constraints:

- $1 \leq \text{prices.length} \leq 10^5$
- $0 \leq \text{prices}[i] \leq 10^4$

## Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> prices {7,6,4,3,1};
5
6     // setup
7     Stopwatch timer;                                // timer-object
8     int p0      {0};                                // first index-pointer
9     int p1      {1};                                // second index-pointer
10    int maxprofit {0};                                // variable to hold max-profit
11    int curr     {-1};                                // variable to hold current-profit
12
13    // going through array
14    while(p1<prices.size()){
15        curr      = prices[p1] - prices[p0];          // calculating current profit
16        maxprofit = curr > maxprofit ? curr : maxprofit; // updating max-profit
17        if (curr < 0) {p0 = p1;}                      // updating p0 if we find lower point
18        ++p1;
19    }
20
21    // printing the final output
22    cout << format("maxprofit = {}\n", maxprofit);
23    timer.stop();
24
25    // return
26    return(0);
27
28 }
```

---

## 122. Best Time To Buy And Sell Stock II

You are given an integer array `prices` where `prices[i]` is the price of a given stock on the *i*th day. On each day, you may decide to buy and/or sell the stock. You can only hold at most one share of the stock at any time. However, you can buy it then immediately sell it on the same day. Find and return the maximum profit you can achieve.

### Examples

#### 1. Example 1

- Input: `prices = [7,1,5,3,6,4]`
- Output: 7
- Explanation: Buy on day 2 (price = 1) and sell on day 3 (price = 5), profit =  $5 - 1 = 4$ . Then buy on day 4 (price = 3) and sell on day 5 (price = 6), profit =  $6 - 3 = 3$ . Total profit is  $4 + 3 = 7$ .

#### 2. Example 2

- Input: `prices = [1,2,3,4,5]`
- Output: 4
- Explanation: Buy on day 1 (price = 1) and sell on day 5 (price = 5), profit =  $5 - 1 = 4$ . Total profit is 4.

#### 3. Example 3

- Input: `prices = [7,6,4,3,1]`
- Output: 0
- Explanation: There is no way to make a positive profit, so we never buy the stock to achieve the maximum profit of 0.



## Constraints

- $1 \leq \text{prices.length} \leq 3 * 10^4$
- $0 \leq \text{prices}[i] \leq 10^4$

## Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> prices {7,1,5,3,6,4};
5
6     // setup
7     int p1      {0};           // index-pointer to buying
8     int p2      {0};           // index-pointer to selling
9     int accprofit {0};         // variable to accumulate profit
10    int currprofit {std::numeric_limits<int>::min()}; // variable to hold curr-profit
11
12    // going through this
13    while(p2 < prices.size()){
14
15        currprofit = prices[p2] - prices[p1];           // calculating current profit
16
17        if (currprofit > 0){
18            accprofit += currprofit;                   // accumulating the profit
19            p1        = p2++;                           // moving the starting point
20            continue;                                   // moving into the next iteration
21        }
22        else if (currprofit < 0){
23            p1        = p2++;                           // moving the starting point
24            continue;
25        }
26    }
```

```
26
27         ++p2;                                // updating p2
28     }
29
30     // printing the max-value
31     cout << format("accprofit = {}\n", accprofit);
32
33     // return
34     return(0);
35
36 }
```

---

## 124. Binary Tree Maximum Path Sum

A path in a binary tree is a sequence of nodes where each pair of adjacent nodes in the sequence has an edge connecting them. A node can only appear in the sequence at most once. Note that the path does not need to pass through the root.

The path sum of a path is the sum of the node's values in the path.

Given the root of a binary tree, return the maximum path sum of any non-empty path.

### Constraints

- The number of nodes in the tree is in the range  $[1, 3 * 10^4]$ .
- $-1000 \leq \text{Node.val} \leq 1000$

### Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto root    {new TreeNode(-10)};
8     root->left    = new TreeNode(9);
9     root->right   = new TreeNode(20);
10    root->right->left = new TreeNode(15);
11    root->right->right = new TreeNode(7);
12
13
14    // setup
```

```

15 auto finalresult {std::numeric_limits<int>::min()};
16
17 // creating lambda
18 std::function<int(const TreeNode*)> fFindMaxPathSum = [&fFindMaxPathSum,
19                                                     &finalresult](
20     const TreeNode* root){
21
22     // checking if leaf-node
23     if(root->left == nullptr && root->right == nullptr){
24
25         // checking the final-result with the leaf-node value
26         finalresult = finalresult > root->val ? finalresult : root->val;
27
28         // the potential from leaf-node
29         return root->val;
30     }
31     else{
32
33         // creating potentials-vector
34         vector<int> potentials;
35         if (root->left) {potentials.emplace_back(fFindMaxPathSum(root->left));}
36         if (root->right) {potentials.emplace_back(fFindMaxPathSum(root->right));}
37
38         // calculating sum of left and right
39         auto leftplusright {0};
40         for(int i = 0; i<potentials.size(); ++i) {leftplusright += potentials[i];}
41
42         // calculating sum of path curr with either paths
43         for(int i = 0; i<potentials.size(); ++i) {potentials[i] += root->val;}
44
45         // adding curr-value alone as a candidate
46         potentials.push_back(root->val);
47
48         // sending the maximum-value back
49         const auto maxelement = *(std::max_element(potentials.begin(), potentials.end()));

```

```

50
51 // path from left-curr-right
52 potentials.push_back(leftplusright + root->val);
53
54 // auto temp = *(std::max_element(potentials.begin(), potentials.end()));
55 const auto comparativemax = *(std::max_element(potentials.begin(), potentials.end()));
56
57 // finalresult = std::max(finalresult, maxelement);
58 finalresult = finalresult > comparativemax ? finalresult : comparativemax;
59
60 // returning the max-potential from here
61 return maxelement;
62 }
63 };
64
65
66 // calculating the final-result
67 fFindMaxPathSum(root);
68
69 // printing
70 cout << format("final-result = {}\n", finalresult);
71
72 // return
73 return(0);
74
75 }

```

---

## 125. Valid Palindrome

A phrase is a palindrome if, after converting all uppercase letters into lowercase letters and removing all non-alphanumeric characters, it reads the same forward and backward. Alphanumeric characters include letters and numbers. Given a string *s*, return true if it is a palindrome, or false otherwise.

### Examples

#### 1. Example 1:

- Input: *s* = "A man, a plan, a canal: Panama"
- Output: true
- Explanation: "amanaplanacanalpanama" is a palindrome.

#### 2. Example 2:

- Input: *s* = "race a car"
- Output: false
- Explanation: "raceacar" is not a palindrome.

#### 3. Example 3:

- Input: *s* = ""
- Output: true
- Explanation: *s* is an empty string "" after removing non-alphanumeric characters. Since an empty string reads the same forward and backward, it is a palindrome.

## Constraints

- $1 \leq s.length \leq 2 * 10^5$
- s consists only of printable ASCII characters.

## Code

---

```
1 int main(){
2
3     // input- configuration
4     auto s = string("A man, a plan, a canal: Panama");
5
6     // setup
7     auto pleft      {0};
8     auto pright     {static_cast<int>(s.size())-1};
9     auto finaloutput {true};
10
11     // lambda to check if alphanumeric
12     auto isalphanumeric = [](const int& x){
13         if (x-65 >= 0 && 90-x >= 0) {return true;} // upper-case check
14         if (x-97 >= 0 && 122-x >= 0) {return true;} // lower-case check
15         if (x-48 >= 0 && 57-x >= 0) {return true;} // numeric check
16         return false;
17     };
18
19     // running
20     while(pleft < s.size() && pright >= 0){
21
22         // moving pleft until we find the position
23         while(pleft < s.size() && isalphanumeric(s[pleft]) == false) {++pleft;}
24         while(pright >= 0 && isalphanumeric(s[pright]) == false) {--pright;}
25     }
```

```
26     // checking bounds
27     if (pleft>=pright) {break;}
28
29     // checking if they're the same
30     if (std::tolower(s[pleft]) != std::tolower(s[pright])) {finaloutput = false; break;}
31
32     // updating pointers
33     ++pleft; --pright;
34 }
35
36 // printing
37 cout << format("final-output = {}\n", finaloutput);
38
39 // return
40 return(0);
41
42 }
```

---



## 127. Word Ladder

A transformation sequence from word `beginWord` to word `endWord` using a dictionary `wordList` is a sequence of words `beginWord`  $\rightarrow$  `s1`  $\rightarrow$  `s2`  $\rightarrow$  ...  $\rightarrow$  `sk` such that:

- Every adjacent pair of words differs by a single letter.
- Every `si` for  $1 \leq i \leq k$  is in `wordList`. Note that `beginWord` does not need to be in `wordList`.
- `sk == endWord`

Given two words, `beginWord` and `endWord`, and a dictionary `wordList`, return the number of words in the shortest transformation sequence from `beginWord` to `endWord`, or 0 if no such sequence exists.

### Examples

#### 1. Example 1:

- Input: `beginWord` = "hit", `endWord` = "cog", `wordList` = ["hot","dot","dog","lot","log","cog"]
- Output: 5
- Explanation: One shortest transformation sequence is "hit"  $\rightarrow$  "hot"  $\rightarrow$  "dot"  $\rightarrow$  "dog"  $\rightarrow$  "cog", which is 5 words long.

#### 2. Example 2:

- Input: `beginWord` = "hit", `endWord` = "cog", `wordList` = ["hot","dot","dog","lot","log"]
- Output: 0
- Explanation: The endWord "cog" is not in wordList, therefore there is no valid transformation sequence.

## Constraints

- $1 \leq \text{beginWord.length} \leq 10$
- $\text{endWord.length} == \text{beginWord.length}$
- $1 \leq \text{wordList.length} \leq 5000$
- $\text{wordList}[i].\text{length} == \text{beginWord.length}$
- $\text{beginWord}$ ,  $\text{endWord}$ , and  $\text{wordList}[i]$  consist of lowercase English letters.
- $\text{beginWord} \neq \text{endWord}$
- All the words in  $\text{wordList}$  are unique.

## Code

---

```
1 // main-file =====
2 int main(){
3
4     // starting timer
5     Timer timer;
6
7     // input- configuration
8     string beginWord    {"hit"};
9     string endWord      {"cog"};
10    vector<string> wordList {
11        "hot","dot","dog","lot","log"
12    };
13
14    // returning error if endword is not in wordhlist
15    if (std::find(wordList.begin(), wordList.end(), endWord) == wordList.end()) {
```

```

16     cout << format("final-output = 0\n");
17     return 0;
18 }
19
20 // setup
21 unordered_map<string, std::set<string> > neighbours;
22
23 auto calculatedistances = [](const string a, const string b){
24     auto numdiffs {0};
25     for(int i = 0; i<a.size(); ++i) {if (a[i] != b[i]) {++numdiffs;}}
26     if (numdiffs == 0)           {return 0;}
27     else if (numdiffs == 1)      {return 1;}
28     else                         {return std::numeric_limits<int>::max();}
29 };
30
31 // starting again
32 vector<string> candidates {beginWord};
33 for(const auto x: wordList) {if (x!=endWord) candidates.push_back(x);}
34 vector<string> nextgencandidates {};
35
36 vector<string> recruiters      {{endWord}};
37 vector<string> nextgenrecruiters {};
38
39 // going through the loop
40 auto count {1};
41 auto runningcondition {true};
42 auto foundpath       {false};
43
44 while(runningcondition){
45     // increasing count
46     ++count;
47
48     // comparing distance between candidates and recruiters
49     for(const auto candidate: candidates){
50

```

```

51     auto shortestpath {std::numeric_limits<int>::max()};
52     for(const auto& recruiter: recruiters)
53         shortestpath = std::min(shortestpath, calculatedistances(candidate, recruiter));
54
55     // adding to next-generation of recruiters if diff == 1
56     if (shortestpath == 1){
57         nextgenrecruiters.push_back(candidate);    // adding to next gen
58         if (candidate == beginWord) {foundpath = true; runningcondition = false;}
59     }
60     else if (shortestpath == std::numeric_limits<int>::max()){
61         nextgencandidates.push_back(candidate);
62     }
63 }
64
65 // rewriting history
66 int prevnumcandidates = candidates.size();
67 int nexnumcandidates = nextgencandidates.size();
68 candidates = nextgencandidates; nextgencandidates.clear();
69 recruiters = nextgenrecruiters; nextgenrecruiters.clear();
70
71 // evaluating running condition
72 if (prevnumcandidates == nexnumcandidates) {runningcondition = false;}
73
74 }
75
76 // setting up final output
77 if (!foundpath) {count = 0;}
78
79 // printing final-output
80 cout << format("final-output = {}\n", count);
81
82
83 // return
84 return(0);
85

```



## 128. Longest Consecutive Sequence

Given an unsorted array of integers `nums`, return the length of the longest consecutive elements sequence.

You must write an algorithm that runs in  $O(n)$  time.

### Examples

#### 1. Example 1:

- Input: `nums = [100,4,200,1,3,2]`
- Output: 4
- Explanation: The longest consecutive elements sequence is `[1, 2, 3, 4]`. Therefore its length is 4.

#### 2. Example 2:

- Input: `nums = [0,3,7,2,5,8,4,6,0,1]`
- Output: 9

#### 3. Example 3:

- Input: `nums = [1,0,1,2]`
- Output: 3

### Constraints

- $0 \leq \text{nums.length} \leq 10^5$
- $-10^9 \leq \text{nums}[i] \leq 10^9$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto nums = vector<int>({0,3,7,2,5,8,4,6,0,1});
8
9     // setup
10    std::multiset<int> var00;
11
12    // trivial-cases
13    if (nums.size() <= 1) {cout << format("final-output = {}\n", nums.size()); return 0;}
14
15    // going through elements
16    for(auto x: nums) {var00.insert(x);}
17
18    // going through elements
19    int maxlength = std::numeric_limits<int>::min();
20    int temp = 1;
21    std::deque<int> var01;
22
23    for(auto x: var00){
24
25        if (var01.size()<1)          {var01.push_back(x);}
26        else{
27            // comparing previous element and current
28            if (x - var01[0] == 1)  {++temp; var01[0] = x; maxlength = max(maxlength, temp);}
29            else if(x - var01[0] == 0) {maxlength = max(maxlength, temp); continue;}
30            else                    {maxlength = max(maxlength, temp); temp = 1; var01[0] = x;}
31        }
32    }
33}
```

```
34 // returning the max-length
35 cout << format("final-output = {}\n", maxlength);
36
37 // return
38 return(0);
39
40 }
```

---



## 129. Sum Root to Leaf Numbers

You are given the root of a binary tree containing digits from 0 to 9 only.

Each root-to-leaf path in the tree represents a number. For example, the root-to-leaf path  $1 \rightarrow 2 \rightarrow 3$  represents the number 123. Return the total sum of all root-to-leaf numbers. Test cases are generated so that the answer will fit in a 32-bit integer.

### Constraints

- The number of nodes in the tree is in the range  $[1, 1000]$ .
- $0 \leq \text{Node.val} \leq 9$
- The depth of the tree will not exceed 10.

### Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto root    {new TreeNode(4)};
8     root->left    = new TreeNode(9);
9     root->right   = new TreeNode(0);
10    root->left->left = new TreeNode(5);
11    root->left->right = new TreeNode(1);
12
13    // trivial case
```

```

14  if (root == nullptr) return 0;
15
16  // setup
17  auto runningsum {0};
18  auto finalSum {0};
19  std::function<void(const TreeNode*, int)> foo = [&foo,
20                                              &finalSum](
21      const TreeNode*   root,
22      int               runningsum){
23
24      // sending it back
25      if (root == nullptr) return;
26
27      // adding current value to running sum
28      runningsum = runningsum*10 + root->val;
29
30      // going down left or right
31      if (root->left || root->right){
32          if (root->left)   foo(root->left,   runningsum);
33          if (root->right)  foo(root->right,  runningsum);
34      }
35      else{
36          // adding to final sum
37          finalSum += runningsum;
38      }
39
40      // return re
41      return;
42  };
43
44  // calling function
45  foo(root, runningsum);
46
47  // returning finalSum
48  cout << format("final-output = {}\n", finalSum);

```

```
49
50     // return
51     return(0);
52
53 }
```

---

## 134. Gas Station

There are  $n$  gas stations along a circular route, where the amount of gas at the  $i$ th station is  $gas[i]$ . You have a car with an unlimited gas tank and it costs  $cost[i]$  of gas to travel from the  $i$ th station to its next  $(i + 1)$ th station. You begin the journey with an empty tank at one of the gas stations. Given two integer arrays  $gas$  and  $cost$ , return the starting gas station's index if you can travel around the circuit once in the clockwise direction, otherwise return  $-1$ . If there exists a solution, it is guaranteed to be unique.

### Examples

#### 1. Example 1:

- Input:  $gas = [1,2,3,4,5]$ ,  $cost = [3,4,5,1,2]$
- Output: 3

#### 2. Example 2:

- Input:  $gas = [2,3,4]$ ,  $cost = [3,4,3]$
- Output: -1

### Constraints:

- $n == gas.length == cost.length$
- $1 \leq n \leq 10^5$
- $0 \leq gas[i], cost[i] \leq 10^4$
- The input is generated such that the answer is unique.

## Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> gas   {1,2,3,4,5};
5     vector<int> cost  {3,4,5,1,2};
6
7     // setup
8     auto acc  {0};
9     vector<int> diffvec;
10    auto temp {0};
11    int finaloutput {-1};
12
13    // running through it
14    for(int i = 0; i<cost.size(); ++i){
15        temp  = gas[i] - cost[i];
16        acc   += temp;
17        diffvec.push_back(temp);
18    }
19    if (acc<0) {finaloutput = -1; return 0;}
20
21    // going through the diff-vec
22    acc = 0;
23    for(int i = 0; i<diffvec.size(); ++i){
24        acc += diffvec[i];
25        if (acc<0) {acc = 0; finaloutput = i+1;}
26    }
27
28
29    // printing the acc
30    cout << format("acc = {}\n", finaloutput);
31
32    // return
33    return(0);
```

34

35

}

---

## 135. Candy

There are  $n$  children standing in a line. Each child is assigned a rating value given in the integer array `ratings`. You are giving candies to these children subjected to the following requirements:

1. Each child must have at least one candy.
2. Children with a higher rating get more candies than their neighbors.
3. Return the minimum number of candies you need to have to distribute the candies to the children.

### Examples

- **Example 1**

- Input: `ratings = [1,0,2]`
- Output: 5
- Explanation: You can allocate to the first, second and third child with 2, 1, 2 candies respectively.

- **Example 2**

- Input: `ratings = [1,2,2]`
- Output: 4
- Explanation: You can allocate to the first, second and third child with 1, 2, 1 candies respectively. The third child gets 1 candy because it satisfies the above two conditions.

## Constraints

1.  $n == \text{ratings.length}$
2.  $1 \leq n \leq 2 * 10^4$
3.  $0 \leq \text{ratings}[i] \leq 2 * 10^4$

## Code

---

```
1 // main-file =====
2 int main(){
3
4     // input- configuration
5     vector<int> ratings {1,0,2};
6
7     // setup
8     auto candies      {std::vector<int>(ratings.size(),1)};
9     auto finaloutput  {static_cast<int>(candies.size())};
10    int leftrating, currrating, rightrating;
11
12    // left-pass
13    for(int i = 1; i<candies.size(); ++i){
14
15        // fetching the rating
16        leftrating = ratings[i-1];
17        currrating = ratings[i];
18
19        // fetching references to candy counts
20        int& leftcount = candies[i-1];
21        int& currcount = candies[i];
22
23        // updating based on left
```



```

24     if (currrating > leftrating){
25         currcount = leftcount+1;
26     }
27 }
28
29 // right pass
30 for(int i = ratings.size()-2; i>=0; --i){
31
32     // fetching ratings
33     currrating = ratings[i];
34     rightrating = ratings[i+1];
35
36     // fetching references to candies
37     int& curr candies = candies[i];
38     int& rightcandies = candies[i+1];
39
40     // updating based on right
41     if (currrating > rightrating){
42         curr candies = std::max(curr candies,
43                                 rightcandies + 1);
44     }
45 }
46
47 // summing up candies
48 finaloutput = std::accumulate(candies.begin(), candies.end(), 0);
49 cout << format("finaloutput = {}\n", finaloutput);
50
51 // return
52 return(0);
53
54 }

```

---

## 137. Single Number II

Given an integer array `nums` where every element appears three times except for one, which appears exactly once. Find the single element and return it.

You must implement a solution with a linear runtime complexity and use only constant extra space.

### Examples

#### 1. Example 1:

- Input: `nums = [2,2,3,2]`
- Output: `3`

#### 2. Example 2:

- Input: `nums = [0,1,0,1,0,1,99]`
- Output: `99`

### Constraints

- $1 \leq \text{nums.length} \leq 3 * 10^4$
- $-2^{31} \leq \text{nums}[i] \leq 2^{31} - 1$
- Each element in `nums` appears exactly three times except for one element which appears once.

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto nums {vector<int>{0,1,99,0,1,0,1}};
8
9     // setup
10    std::unordered_map<int, int> histogram;
11    auto finaloutput {-1};
12
13    // going through the nums
14    for(const auto& x: nums){
15        if (histogram.find(x) == histogram.end()) {histogram[x] = 1;}
16        else {++histogram[x];}
17    }
18
19    // going through the histogram again to see who has count 1
20    for(const auto& [k,v]: histogram){
21        if (v == 1) {finaloutput = k;}
22    }
23
24    // printing the output
25    cout << format("final-output = {}\n", finaloutput);
26
27    // return
28    return(0);
29
30 }
```

---

## 141. 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.

### Examples

#### 1. Example 1:

- Input: head = [3,2,0,-4], pos = 1
- Output: true
- Explanation: There is a cycle in the linked list, where the tail connects to the 1st node (0-indexed).

#### 2. Example 2:

- Input: head = [1,2], pos = 0
- Output: true
- Explanation: There is a cycle in the linked list, where the tail connects to the 0th node.

#### 3. Example 3:

- Input: head = [1], pos = -1
- Output: false
- Explanation: There is no cycle in the linked list.

## Constraints

- The number of the nodes in the list is in the range [0, 104].
- $-10^5 \leq \text{Node.val} \leq 10^5$
- pos is -1 or a valid index in the linked-list.

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     ListNode* head      = new ListNode(3);
8     head->next           = new ListNode(2);
9     head->next->next      = new ListNode(0);
10    head->next->next->next  = new ListNode(-4);
11    head->next->next->next->next = head->next;
12
13    // trivial case
14    if (head == nullptr) {cout << format("final-output = false\n"); return 0;}
15
16    // setup
17    ListNode* dummy      = new ListNode(0);
18    dummy->next           = head;
19    ListNode* fastboi    = dummy;
20    ListNode* slowboi    = dummy;
21
22    while (fastboi != nullptr && fastboi->next != nullptr) {
23
```

```
24     // updating positions
25     fastboi = fastboi->next->next;
26     slowboi = slowboi->next;
27
28     // checking if they're the same
29     if (slowboi == fastboi) {cout << format("final-output = true\n"); return 0;}
30 }
31
32 // since exiting the list implies you left
33 cout << format("final-output = false\n"); return 0;
34
35 // return
36 return(0);
37 }
```

---

## 148. Sort List

Given the head of a linked list, return the list after sorting it in ascending order.

### Constraints

- The number of nodes in the list is in the range  $[0, 5 * 10^4]$ .
- $-105 \leq \text{Node.val} \leq 105$

### Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto head      {new ListNode(4)};
8     head->next      = new ListNode(2);
9     head->next->next  = new ListNode(1);
10    head->next->next->next = new ListNode(3);
11
12    // setup
13    if (head == nullptr) {cout << format("empty-list\n"); return 0;}
14
15    // setup
16    ListNode* traveller = nullptr;
17    vector<pair<int, ListNode*>> nodeaddresses;
18
19    // goign through the list
```

```

20     traveller = head;
21     while(traveller){
22
23         // adding it ot the list
24         nodeaddresses.push_back(std::pair<int, ListNode*>({traveller->val, traveller}));
25
26         // moving on to the next one
27         traveller = traveller->next;
28     }
29
30     // sorting the whole thing
31     std::sort(nodeaddresses.begin(),
32             nodeaddresses.end(),
33             [](pair<int, ListNode*> a,
34               pair<int, ListNode*> b) {return a < b;});
35
36     // reconnecting
37     for(int i = 0; i<nodeaddresses.size()-1; ++i)
38         nodeaddresses[i].second->next = nodeaddresses[i+1].second;
39
40
41     // making the last one connect to nullptr
42     nodeaddresses[nodeaddresses.size()-1].second->next = nullptr;
43
44     // returning top of the list
45     fPrintLinkedList("finalOutput = ", nodeaddresses[0].second);
46
47     // return
48     return(0);
49 }

```

---



## 150. Evaluate Reverse Polish Notation

You are given an array of strings `tokens` that represents an arithmetic expression in a Reverse Polish Notation.

Evaluate the expression. Return an integer that represents the value of the expression.

## 151. Reverse Words In A String

Given an input string *s*, reverse the order of the words. A word is defined as a sequence of non-space characters. The words in *s* will be separated by at least one space. Return a string of the words in reverse order concatenated by a single space. Note that *s* may contain leading or trailing spaces or multiple spaces between two words. The returned string should only have a single space separating the words. Do not include any extra spaces.

### Examples

#### 1. Example 1

- Input: *s* = "the sky is blue"
- Output: "blue is sky the"

#### 2. Example 2

- Input: *s* = " hello world "
- Output: "world hello"
- Explanation: Your reversed string should not contain leading or trailing spaces.

#### 3. Example 3

- Input: *s* = "a good example"
- Output: "example good a"
- Explanation: You need to reduce multiple spaces between two words to a single space in the reversed string.

## Constraints

1.  $1 \leq s.length \leq 10^4$
2. s contains English letters (upper-case and lower-case), digits, and spaces ' '.
3. There is at least one word in s.

## Code

---

```
1 int main(){
2
3     // input- configuration
4     string s {"a good example"};
5
6     // setup
7     vector<string> listofwords;
8
9     // creating a list of words
10    int p1 {0};
11    string acc;
12    while(p1 < s.size()){
13
14        // checking if the current character is a non-space
15        if (s[p1] != ' '){acc += s[p1];}
16        else{
17            // if acc is non-empty, flush
18            if (acc.size() != 0) {listofwords.push_back(acc); acc = "";}
19            else {;}
20        }
21
22        // moving the index-pointer forward
23        p1++;
```

```
24 }
25
26 // check if acc is unflushed
27 if (acc.size() != 0) {listofwords.push_back(acc); acc = "";}
28
29 // building the finaloutput
30 string finaloutput;
31 for(int i = listofwords.size()-1; i>=0; --i){
32     finaloutput += listofwords[i];
33     if (i!=0) [[unlikely]] {finaloutput += " ";}
34 }
35
36 // printing the finaloutput
37 cout << format("finaloutput = {}\n", finaloutput);
38
39
40 // return
41 return(0);
42
43 }
```

---

## 153. Find Minimum in Rotated Sorted Array

Suppose an array of length  $n$  sorted in ascending order is rotated between 1 and  $n$  times. For example, the array `nums = [0,1,2,4,5,6,7]` might become:

- `[4,5,6,7,0,1,2]` if it was rotated 4 times.
- `[0,1,2,4,5,6,7]` if it was rotated 7 times.

Notice that rotating an array `[a[0], a[1], a[2], ..., a[n-1]]` 1 time results in the array `[a[n-1], a[0], a[1], a[2], ..., a[n-2]]`.

Given the sorted rotated array `nums` of unique elements, return the minimum element of this array.

You must write an algorithm that runs in  $O(\log n)$  time.

### Examples

#### 1. Example 1:

- Input: `nums = [3,4,5,1,2]`
- Output: 1
- Explanation: The original array was `[1,2,3,4,5]` rotated 3 times.

#### 2. Example 2:

- Input: `nums = [4,5,6,7,0,1,2]`
- Output: 0
- Explanation: The original array was `[0,1,2,4,5,6,7]` and it was rotated 4 times.

### 3. Example 3:

- Input: nums = [11,13,15,17]
- Output: 11
- Explanation: The original array was [11,13,15,17] and it was rotated 4 times.

### Constraints

- $n == \text{nums.length}$
- $1 \leq n \leq 5000$
- $-5000 \leq \text{nums}[i] \leq 5000$
- All the integers of nums are unique.
- nums is sorted and rotated between 1 and n times.

### Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto nums {vector<int>{3,4,5,1,2}};
8
9     // setup
10    auto left {0};
```

```
11 auto right {static_cast<int>(nums.size()-1)};
12 auto mid {-1};
13
14 // looping through
15 while(left < right){
16
17     // calculating midpoint
18     mid = (left + right)/2;
19
20     // moving pointers
21     if(nums[mid] > nums[right]) {left = mid + 1;}
22     else {right = mid;}
23 }
24
25 // returning the mid-value
26 cout << format("final-output = {}\n", nums[left]);
27
28 // return
29 return(0);
30
31 }
```

---

## 162. Find Peak Element

A peak element is an element that is strictly greater than its neighbors.

Given a 0-indexed integer array `nums`, find a peak element, and return its index. If the array contains multiple peaks, return the index to any of the peaks.

You may imagine that  $\text{nums}[-1] = \text{nums}[n] = -\infty$ . In other words, an element is always considered to be strictly greater than a neighbor that is outside the array.

You must write an algorithm that runs in  $O(\log n)$  time.

### Examples

#### 1. Example 1:

- Input: `nums = [1,2,3,1]`
- Output: 2
- Explanation: 3 is a peak element and your function should return the index number 2.

#### 2. Example 2:

- Input: `nums = [1,2,1,3,5,6,4]`
- Output: 5
- Explanation: Your function can return either index number 1 where the peak element is 2, or index number 5 where the peak element is 6.



## Constraints

- $1 \leq \text{nums.length} \leq 1000$
- $-2^{31} \leq \text{nums}[i] \leq 2^{31} - 1$
- $\text{nums}[i] \neq \text{nums}[i + 1]$  for all valid  $i$ .

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto nums = {vector<int>{1,2,3,1}};
8
9     // setup
10    int left = {0};
11    int right = {static_cast<int>(nums.size())-1};
12    int mid = {-1};
13
14    // running the lopo
15    while(left <= right){
16
17        // fetching middle index
18        mid = (left + right)/2;
19
20        // evaluating
21        if (mid > 0 && nums[mid] < nums[mid-1]) {right = mid-1;}
22        else if (mid < nums.size()-1 && nums[mid] < nums[mid+1]) {left = mid +1;}
23        else {break;}
```

```
24     }
25
26     // returning mid
27     cout << format("final-output = {}\n", mid);
28
29     // return
30     return(0);
31
32 }
```

---

## 167. Two Sum II - Input Array Is Sorted

Given a 1-indexed array of integers `numbers` that is already sorted in non-decreasing order, find two numbers such that they add up to a specific target number. Let these two numbers be `numbers[index1]` and `numbers[index2]` where  $1 \leq \text{index1} < \text{index2} \leq \text{numbers.length}$ .

Return the indices of the two numbers, `index1` and `index2`, added by one as an integer array `[index1, index2]` of length 2.

The tests are generated such that there is exactly one solution. You may not use the same element twice.

Your solution must use only constant extra space.

### Examples

#### 1. Example 1:

- Input: `numbers = [2,7,11,15]`, `target = 9`
- Output: `[1,2]`
- Explanation: The sum of 2 and 7 is 9. Therefore, `index1 = 1`, `index2 = 2`. We return `[1, 2]`.

#### 2. Example 2:

- Input: `numbers = [2,3,4]`, `target = 6`
- Output: `[1,3]`
- Explanation: The sum of 2 and 4 is 6. Therefore `index1 = 1`, `index2 = 3`. We return `[1, 3]`.

#### 3. Example 3:

- Input: `numbers = [-1,0]`, `target = -1`

- Output: [1,2]
- Explanation: The sum of -1 and 0 is -1. Therefore index1 = 1, index2 = 2. We return [1, 2].

## Constraints

- $2 \leq \text{numbers.length} \leq 3 * 10^4$
- $-1000 \leq \text{numbers}[i] \leq 1000$
- numbers is sorted in non-decreasing order.
- $-1000 \leq \text{target} \leq 1000$
- The tests are generated such that there is exactly one solution.

## Code

---

```
1 int main(){
2
3     // input- configuration
4     auto numbers = vector<int>{2,7,11,15};
5     auto target  = 9;
6
7     // setup
8     std::vector<int> finalOutput;
9     auto left    {0};
10    auto right    {static_cast<int>(numbers.size()-1)};
11    auto currsum  {0};
12
13    // usual left-right loop
14    while (left < right){
```

```
15
16 // checking sum of two values
17 currsum = numbers[left] + numbers[right];
18
19 // comparing against target
20 if (currsum > target)    {--right;}
21 else if (currsum < target) {++left;}
22 else {
23     finalOutput.push_back( left+1);
24     finalOutput.push_back( right+1);
25     break;
26 }
27 }
28
29 // printign the final output
30 cout << format("finaloutput = {}\n", finalOutput);
31
32 // return
33 return(0);
34
35 }
```

---

## 169 Majority Element

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

### Examples

- **Example 1**

- Input: `nums = [3,2,3]`
- Output: `3`

- **Example 2**

- Input: `nums = [2,2,1,1,1,2,2]`
- Output: `2`

### Constraints:

- `n == nums.length`
- $1 \leq n \leq 5 * 10^4$
- $-10^9 \leq \text{nums}[i] \leq 10^9$

## Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> nums {2,2,1,1,1,2,2};
5
6     // setup
7     unordered_map<int, int> histogram;
8     int max_element {std::numeric_limits<int>::min()};
9     int max_count {std::numeric_limits<int>::min()};
10    int updated_count {0};
11
12    // going through the elements
13    for(int i = 0; i<nums.size(); ++i){
14
15        // adding to histogram
16        if (histogram.find(nums[i]) == histogram.end()) {histogram[nums[i]] = 1; updated_count = 0;}
17        else {++histogram[nums[i]]; updated_count = histogram[nums[i]];}
18
19        // keeping track of max-element
20        if (updated_count > max_count) {max_element = nums[i]; max_count = updated_count;}
21
22    }
23
24    // printing the final output
25    cout << format("nums = "); fpv(nums);
26    cout << format("max-count = {}\n", max_count);
27
28    // return
29    return(0);
30
31 }
```

---

## 172. Factorial Trailing Zeroes

Given an integer  $n$ , return the number of trailing zeroes in  $n!$ .

Note that  $n! = n * (n - 1) * (n - 2) * \dots * 3 * 2 * 1$ .

### Examples

#### 1. Example 1:

- Input:  $n = 3$
- Output: 0
- Explanation:  $3! = 6$ , no trailing zero.

#### 2. Example 2:

- Input:  $n = 5$
- Output: 1
- Explanation:  $5! = 120$ , one trailing zero.

#### 3. Example 3:

- Input:  $n = 0$
- Output: 0

### Constraints

- $0 \leq n \leq 10^4$



## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto n {5};
8
9     // setting up lambdas
10    auto counttwos    = [](int x){
11
12        // in case of x == 0 or x being odd
13        if(x%2 != 0 || x == 0) {return 0;}
14
15        // counting number of 2s we can pluck from this number
16        auto numtwos {0};
17        while(true){
18            if (x%2 == 0) {++numtwos; x /= 2; continue;}
19            else          {return numtwos;}
20        }
21
22        // returning
23        return numtwos;
24    };
25
26    auto countfives    = [](int x){
27
28        // in case of x == 0 or x not being a multiple of five
29        if(x%5 != 0 || x == 0)          {return 0;}
30
31        // counting number of 5s we can pluck from this number
32        auto numfives {0};
33        while(true){
```

```

34         if (x%5 == 0) {++numfives; x /= 5; continue;}
35         else          {return numfives;}
36     }
37
38     // returning numfives
39     return numfives;
40 };
41
42 // calculating numtwos and numfives
43 auto numtwos {0};
44 auto numfives {0};
45
46 for(int i = n; i>=0; --i){
47
48     numtwos    += counttwos(i);
49     numfives    += countfives(i);
50
51 }
52
53 // calculating numzeros
54 auto finaloutput {std::min(numtwos, numfives)};
55 cout << format("final-output = {}\n", finaloutput);
56
57 // return
58 return(0);
59
60 }

```

---

## 189 Rotate Array

Given an integer array `nums`, rotate the array to the right by `k` steps, where `k` is non-negative.

### Examples

- **Example 1**
  - Input: `nums = [1,2,3,4,5,6,7]`, `k = 3`
  - Output: `[5,6,7,1,2,3,4]`
- **Example 1**
  - Input: `nums = [-1,-100,3,99]`, `k = 2`
  - Output: `[3,99,-1,-100]`

### Constraints

- $1 \leq \text{nums.length} \leq 10^5$
- $-2^31 \leq \text{nums}[i] \leq 2^31 - 1$
- $0 \leq k \leq 10^5$

## Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> nums {-1,-100,3,99};
5     int k {2};
6
7     // setup
8     Stopwatch timer;                                // setting up the timer
9     k = k %static_cast<int>(nums.size());           // to ensure that the value is within range
10
11     int source {0};
12     int temp_source {nums[source]};
13     int temp {0};
14     int destination {0};
15
16     vector<bool> sourcelist(nums.size(), false);
17
18     // going through nums
19     for(int i = 0; i < nums.size(); ++i){
20
21         // check if curent-source has been taken care of
22         if (sourcelist[source] == true){
23             source = (source+1) % nums.size();
24             temp_source = nums[source];
25         }
26
27         source = source % nums.size();               // code to ensure range
28         destination = (source + k)%nums.size();     // calculating the index we'll be writing to
29         sourcelist[source] = true;                  // updating source-list
30
31         temp = nums[destination];                   // safe-keeping the destination value
32         nums[destination] = temp_source;            // storing new value at destination-index
33     }
```

```
34     source          = destination;           // updating source-index
35     temp_source      = temp;                 // updating source-value
36 }
37
38 // printing the output
39 cout << format("nums = "); fpv(nums);        // printing the updated array, "nums"
40 timer.stop();                                // printing the time taken
41
42 // return
43 return(0);
44 }
```

---

## 190. Reverse Bits

Reverse bits of a given 32 bits signed integer.

### Examples

#### 1. Example 1:

- Input: n = 43261596
- Output: 964176192
- Explanation:

Integer	Binary
43261596	00000010100101000001111010011100
964176192	00111001011110000010100101000000

#### 2. Example 2:

- Input: n = 2147483644
- Output: 1073741822
- Explanation:

Integer	Binary
2147483644	01111111111111111111111111111100
1073741822	00111111111111111111111111111110

## Constraints

- $0 \leq n \leq 2^{31} - 2$
- n is even.

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     uint32_t n = 43261596;
8
9     // reversing
10    uint32_t n_reverse = 0b0;
11
12    // reversing loop
13    for (int i = 0; i<32; ++i) {
14        // making space for reverse number and adding current
15        n_reverse = n_reverse<<1 | (n & 1);
16
17        // cutting off tail.
18        n = n>>1;
19    }
20
21    // returning the final output
22    cout << format("final-output = {}\n", n_reverse);
23
24    // return
25    return(0);
```

26

27

}



## 191. Number of 1 Bits

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).

### Examples

#### 1. Example 1:

- Input:  $n = 11$
- Output: 3
- Explanation: The input binary string 1011 has a total of three set bits.

#### 2. Example 2:

- Input:  $n = 128$
- Output: 1
- Explanation: The input binary string 10000000 has a total of one set bit.

#### 3. Example 3:

- Input:  $n = 2147483645$
- Output: 30
- Explanation: The input binary string 111111111111111111111111111101 has a total of thirty set bits.

### Constraints

- $1 \leq n \leq 2^{31} - 1$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto n {11};
8
9     // setup
10    int count = 0;;
11    while (n) {
12        if ((n & 1)==1) ++count;
13        n = n >> 1;
14    }
15
16    // printing the final-output
17    cout << format("final-output = {}\n", count);
18
19    // return
20    return(0);
21
22 }
```

---

## 198. House Robber

You are a professional robber planning to rob houses along a street. Each house has a certain amount of money stashed, the only constraint stopping you from robbing each of them is that adjacent houses have security systems connected and it will automatically contact the police if two adjacent houses were broken into on the same night.

Given an integer array `nums` representing the amount of money of each house, return the maximum amount of money you can rob tonight without alerting the police.

### Examples

#### 1. Example 1:

- Input: `nums = [1,2,3,1]`
- Output: 4
- Explanation: Rob house 1 (money = 1) and then rob house 3 (money = 3).  
Total amount you can rob =  $1 + 3 = 4$ .

#### 2. Example 2:

- Input: `nums = [2,7,9,3,1]`
- Output: 12
- Explanation: Rob house 1 (money = 2), rob house 3 (money = 9) and rob house 5 (money = 1).  
Total amount you can rob =  $2 + 9 + 1 = 12$ .

## Constraints

- $1 \leq \text{nums.length} \leq 100$
- $0 \leq \text{nums}[i] \leq 400$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto nums {vector<int>{1,2,3,1}};
8
9     // setup
10    std::vector<int> dp{nums[0]};
11    int maxCandidate;
12
13    // building the dp-table
14    for(int i = 1; i<nums.size(); ++i){
15
16        // checking which max value to use
17        if (i > 1) {maxCandidate = std::max(nums[i]+ dp[i-2], dp[i-1]);}
18        else      {maxCandidate = std::max(nums[i], dp[i-1]);}
19
20        // storing max-candidate
21        dp.push_back(maxCandidate);
22    }
23
24    // returning
25    cout << format("final-output = {}\n", dp[dp.size()-1]);
```

```
26
27 // return
28 return(0);
29
30 }
```

---

## 200. Number of Islands

Given an  $m \times n$  2D binary grid `grid` which represents a map of '1's (land) and '0's (water), return the number of islands.

An island is surrounded by water and is formed by connecting adjacent lands horizontally or vertically. You may assume all four edges of the grid are all surrounded by water.

### Examples

#### 1. Example 1:

- Input:

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

- Output: 1

#### 2. Example 2:

- Input:

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

- Output: 3

### Constraints

- $m == \text{grid.length}$

- $n == \text{grid}[i].\text{length}$
- $1 \leq m, n \leq 300$
- $\text{grid}[i][j]$  is '0' or '1'.

## Code

---

```

1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     vector<vector<string>> grid {
8         vector<string>({"1","1","1","1","0"}),
9         vector<string>({"1","1","0","1","0"}),
10        vector<string>({"1","1","0","0","0"}),
11        vector<string>({"0","0","0","0","0"})
12    };
13
14    // setup
15    std::vector< std::vector<bool> > didWeVisitThisPlace;
16    for(int i = 0; i<grid.size(); ++i)
17        didWeVisitThisPlace.push_back(std::vector<bool>(grid[0].size(), false));
18
19    // lambda to check validity
20    auto fCheckValidityOfCoordinate = [&grid](
21        std::vector<int> coords){
22
23        // spreading it out
24        auto row {coords[0]};
25        auto col {coords[1]};

```

```

26
27 // checking validity
28 if (row >= 0      &&
29     row < grid.size() &&
30     col >= 0      &&
31     col < grid[0].size())
32     if (grid[row][col] == "1") {return true;}
33
34 // in case the above condition is not met
35 return false;
36
37 };
38
39 // traversal function
40 std::function<void(int, int)> fMarkThemAll = [&fMarkThemAll,
41                                             &grid,
42                                             &didWeVisitThisPlace,
43                                             fCheckValidityOfCoordinate](
44     int row_index,
45     int col_index){
46
47     // setting up coordinates
48     std::vector<int> rightCoordinate({row_index, col_index+1});
49     std::vector<int> downCoordinate{row_index+1, col_index};
50
51     // marking the current coordinate as visited
52     didWeVisitThisPlace[row_index][col_index] = true;
53
54     // calling the function to the right
55     if (fCheckValidityOfCoordinate(rightCoordinate) == true && \
56         didWeVisitThisPlace[rightCoordinate[0]][rightCoordinate[1]] == false)
57         fMarkThemAll(rightCoordinate[0], rightCoordinate[1]);
58
59     // calling the function for the ones below
60     if (fCheckValidityOfCoordinate(downCoordinate) == true && \

```



```

61         didWeVisitThisPlace[downCoordinate[0]][downCoordinate[1]] == false)
62             fMarkThemAll(downCoordinate[0], downCoordinate[1]);
63     };
64
65
66     // going through the elements
67     int count = 0;
68     for(int row_index = 0; row_index < grid.size(); ++row_index){
69         for(int col_index = 0; col_index < grid[0].size(); ++col_index){
70             // starting an exploratory course if this point has not been visited
71             if (didWeVisitThisPlace[row_index][col_index] == false && \
72                 grid[row_index][col_index] == "1"){
73                 fMarkThemAll(row_index, col_index);
74                 ++count;
75             }
76         }
77     }
78
79     // return count
80     cout << format("final-output = {}\n", count);
81
82     // return
83     return(0);
84
85 }

```

---

## 202. Happy Number

Write an algorithm to determine if a number  $n$  is happy.

A happy number is a number defined by the following process:

1. Starting with any positive integer, replace the number by the sum of the squares of its digits.
2. Repeat the process until the number equals 1 (where it will stay), or it loops endlessly in a cycle which does not include 1.
3. Those numbers for which this process ends in 1 are happy.

Return true if  $n$  is a happy number, and false if not.

### Examples

#### 1. Example 1:

- Input:  $n = 19$
- Output: true
- Explanation:
  - $1^2 + 9^2 = 82$
  - $8^2 + 2^2 = 68$
  - $6^2 + 8^2 = 100$
  - $1^2 + 0^2 + 0^2 = 1$

#### 2. Example 2:

- Input:  $n = 2$
- Output: false

## Constraints

- $1 \leq n \leq 2^31 - 1$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto n {19};
8
9     // trivial case
10    if (n == 4 || n == 0) {cout << format("final-output = false\n"); return 0;}
11
12    // setting up lambda
13    auto fSumDigitSquares = [](int n) -> int
14    {
15        auto sum {0};
16        auto digit {-1};
17        while(n!=0){
18            digit = n%10;
19            sum += digit*digit;
20            n = n/10;
21        }
22        return sum;
23    };
24
25    // calling the function
26    while (n != 1){
27        // calculating digits sums
```

```
28     n = fSumDigitSquares(n); cout << format("n = {}\n", n);
29     if (n == 4 || n == 0)      {cout << format("final-output = false\n"); return 0;}
30 }
31
32 // printing and returning
33 cout << format("final-output = true \n"); return 0;
34
35 }
```

---

## 205. Isomorphic Strings

Given two strings  $s$  and  $t$ , determine if they are isomorphic.

Two strings  $s$  and  $t$  are isomorphic if the characters in  $s$  can be replaced to get  $t$ .

All occurrences of a character must be replaced with another character while preserving the order of characters. No two characters may map to the same character, but a character may map to itself.

### Examples

#### 1. Example 1:

- Input:  $s = \text{"egg"}, t = \text{"add"}$
- Output: true
- Explanation: The strings  $s$  and  $t$  can be made identical by:
  - Mapping 'e' to 'a'.
  - Mapping 'g' to 'd'.

#### 2. Example 2:

- Input:  $s = \text{"foo"}, t = \text{"bar"}$
- Output: false
- Explanation: The strings  $s$  and  $t$  can not be made identical as 'o' needs to be mapped to both 'a' and 'r'.

#### 3. Example 3:

- Input:  $s = \text{"paper"}, t = \text{"title"}$
- Output: true

## Constraints:

- $1 \leq s.length \leq 5 * 10^4$
- $t.length == s.length$
- $s$  and  $t$  consist of any valid ascii character.

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     string s = {"egg"};
8     string t = {"add"};
9
10    // making mapping
11    unordered_map<char, char> mapping;
12    std::unordered_set<char> destinations;
13    string      r;
14
15    // going through string
16    for(int i = 0; i<s.size(); ++i){
17
18        // checking if two strings are different
19        if (s[i] != t[i]){
20            // checking if we already have a mapping for this
21            if (mapping.find(s[i]) == mapping.end()){
22
23                // before we add, we need to check if t[i] is already used as a destination
```

```

24     if (destinations.find(t[i]) != destinations.end()) {
25         cout << format("final-output = true \n");
26         return 0;
27     }
28
29     // adding new mapping
30     mapping[s[i]] = t[i];
31     destinations.insert(t[i]);
32 }
33 r.push_back(mapping[s[i]]);
34 }
35 else{
36     // checking if we already have a mapping for this
37     if (mapping.find(s[i]) == mapping.end()){
38
39         // before we add, we need to check if t[i] is already used as a destination
40         if (destinations.find(t[i]) != destinations.end()) {
41             cout << format("final-output = true \n");
42             return 0;
43         }
44
45         // adding new mapping
46         mapping[s[i]] = s[i];
47         destinations.insert(s[i]);
48     }
49     r.push_back(mapping[s[i]]);
50 }
51
52 // if what we have so far is different, we're sending it back
53 string s_subset(t.begin(), t.begin() + r.size());
54 if(s_subset != r) {cout << format("final-output = false \n"); return 0;}
55
56 }
57
58 // return true in the end

```

```
59     cout << format("final-output = true \n");
60
61     // return
62     return(0);
63 }
```

---



## 207. Course Schedule

There are a total of `numCourses` courses you have to take, labeled from 0 to `numCourses - 1`. You are given an array `prerequisites` where `prerequisites[i] = [ai, bi]` indicates that you must take course `bi` first if you want to take course `ai`.

For example, the pair `[0, 1]`, indicates that to take course 0 you have to first take course 1. Return `true` if you can finish all courses. Otherwise, return `false`.

### Examples

#### 1. Example 1:

- Input: `numCourses = 2, prerequisites = [[1,0]]`
- Output: `true`
- Explanation: There are a total of 2 courses to take.
  - To take course 1 you should have finished course 0. So it is possible.

#### 2. Example 2:

- Input: `numCourses = 2, prerequisites = [[1,0],[0,1]]`
- Output: `false`
- Explanation: There are a total of 2 courses to take.
  - To take course 1 you should have finished course 0, and to take course 0 you should also have finished course 1. So it is impossible.

## Constraints

- $1 \leq \text{numCourses} \leq 2000$
- $0 \leq \text{prerequisites.length} \leq 5000$
- $\text{prerequisites}[i].\text{length} == 2$
- $0 \leq a_i, b_i < \text{numCourses}$
- All the pairs  $\text{prerequisites}[i]$  are unique.

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto numCourses {2};
8     vector<vector<int>> prerequisites {
9         {1,0},
10        {1,2},
11        {0,1}
12    };
13
14    // setup
15    vector<bool> visited(numCourses, false);
16    vector<bool> hasPrerequisite(numCourses, false);
17    unordered_map<int, vector<int>> hmap;
18
19    // build prerequisite list
```

```

20 for(const auto x: prerequisites){
21
22     // pickign things out
23     auto curr {x[0]};
24     auto prereq {x[1]};
25
26     // setting the flag for non
27     hasPrerequisite[curr] = true;
28
29     // adding to the hashmap
30     if(hmap.find(prereq) == hmap.end()) {hmap[prereq] = vector<int>{curr};}
31     else {hmap[prereq].push_back(curr);}
32
33 }
34
35 // find no-prerequisite course
36 std::deque<int> indiceswithnoprerequisites;
37 for(int i = 0; i<numCourses;++i)
38     if (hasPrerequisite[i]==false)
39         indiceswithnoprerequisites.push_back(i);
40
41 // start from there and flag the
42 std::deque<int> prev;
43 while(indiceswithnoprerequisites.size()!=0 && prev != indiceswithnoprerequisites){
44
45     // storing for later comparison
46     prev = indiceswithnoprerequisites;
47
48     // popping the front
49     auto front {indiceswithnoprerequisites.front()};
50     indiceswithnoprerequisites.pop_front();
51
52     // launching search from "front"
53     if (hmap.find(front) == hmap.end()) {
54         visited[front] = true;

```

```

55     continue;
56 }
57 else {
58     visited[front] = true;
59     auto& bruh {hmap[front]};
60     for(const auto& x: bruh) {
61         if (visited[x] == false) {indiceswithnoprerequisites.push_back(x);}
62         visited[x] = true;
63     }
64 }
65 }
66
67
68 // finalizing output
69 auto finaloutput {true};
70 for(int i = 0; i<visited.size(); ++i) {finaloutput = finaloutput&&visited[i];}
71 cout << format("final-output = {}\n", finaloutput);
72
73 // return
74 return(0);
75
76 }

```

---

## 209. Minimum Size Subarray Sum

Given an array of positive integers `nums` and a positive integer `target`, return the minimal length of a subarray whose sum is greater than or equal to `target`. If there is no such subarray, return 0 instead.

### Examples

#### 1. Example 1:

- Input: `target = 7`, `nums = [2,3,1,2,4,3]`
- Output: 2
- Explanation: The subarray `[4,3]` has the minimal length under the problem constraint.

#### 2. Example 2:

- Input: `target = 4`, `nums = [1,4,4]`
- Output: 1

#### 3. Example 3:

- Input: `target = 11`, `nums = [1,1,1,1,1,1,1,1]`
- Output: 0

### Constraints

- $1 \leq \text{target} \leq 10^9$

- $1 \leq \text{nums.length} \leq 10^5$
- $1 \leq \text{nums}[i] \leq 10^4$

## Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> nums {1,2,3,4,5};
5     auto target {15};
6
7     // setup
8     auto finaloutput {std::numeric_limits<int>::max()};
9     auto pleft {0};
10    auto sum {nums[pleft]};
11    auto i {1};
12
13    // in case the first element itself is greater
14    if (sum > target) {finaloutput = 1;}
15
16    // lambda to update finaloutput
17    auto updatefinaloutput = [&sum,
18                             &target,
19                             &finaloutput,
20                             &i,
21                             &pleft,
22                             &nums]() -> void{
23
24        auto numelements = i - pleft + 1;
25        finaloutput = numelements < finaloutput ? numelements : finaloutput;
26        sum -= nums[pleft++];
27    };
```

```
28
29 // going through the array
30 for(; i<nums.size(); ++i){
31
32     // adding to sum
33     sum += nums[i];
34
35     // updating
36     while (sum>=target) {updatefinaloutput();}
37 }
38
39 // updating
40 if(finaloutput == std::numeric_limits<int>::max()) {finaloutput = 0;}
41
42 // printing the finaloutput
43 cout << format("finaloutput = {}\n", finaloutput);
44
45 // return
46 return(0);
47
48 }
```

---

## 212. Word Search II

Given an  $m \times n$  board of characters and a list of strings words, return all words on the board.

Each word must be constructed from letters of sequentially adjacent cells, where adjacent cells are horizontally or vertically neighboring. The same letter cell may not be used more than once in a word.

### Examples

#### 1. Example 1:

- Input: board = `[["o","a","a","n"],["e","t","a","e"],["i","h","k","r"],["i","f","l","v"]]`, words = `["oath","pea"]`
- Output: `["eat","oath"]`

#### 2. Example 2:

- Input: board = `[["a","b"],["c","d"]]`, words = `["abcb"]`
- Output: `[]`

### Constraints

- $m == \text{board.length}$
- $n == \text{board}[i].\text{length}$
- $1 \leq m, n \leq 12$
- `board[i][j]` is a lowercase English letter.



- $1 \leq \text{words.length} \leq 3 * 10^4$
- $1 \leq \text{words}[i].\text{length} \leq 10$
- $\text{words}[i]$  consists of lowercase English letters.
- All the strings of words are unique.

## Code

---

```

1 void foo(const vector<vector<char>>& board,
2         const int
3         const int
4         const string&
5         bool&
6         vector<int>
7         std::function<int(const int&, const int&)> tid,
8         std::function<int(const int)>
9         std::function<int(const int)>
10
11 // if found is done
12 if (found == true) {return;}
13
14 // returning if tid is beyond the bounds
15 if (curr_tid >= (board.size() * board[0].size())) {return;}
16
17 // calculating curr-row and col
18 const auto rowcurr {row(curr_tid)}; if (rowcurr < 0 || rowcurr >= board.size()) {return;}
19 const auto colcurr {col(curr_tid)}; if (colcurr < 0 || colcurr >= board[0].size()) {return;}
20
21 // check: duplicate tid in path
22 if (std::find(pathsofar.begin(), pathsofar.end(), curr_tid) != pathsofar.end()) {return;}
23

```

```

24 // check: target-char vs curr-char
25 char curr_char          {board[rowcurr][colcurr]};
26 char charwererearchingfor {targetword[p]};
27 if (curr_char != charwererearchingfor)                                {return;}
28
29 // adding to path
30 pathsofar.push_back(curr_tid);
31
32 // checking if we've reached the end
33 if (pathsofar.size() == targetword.size()) {found = true; return;}
34
35 // moving into the neighbours
36 foo(board, p+1, tid(rowcurr, colcurr+1), targetword, found, pathsofar, tid, row, col); // moving right
37 foo(board, p+1, tid(rowcurr-1, colcurr), targetword, found, pathsofar, tid, row, col); // moving up
38 foo(board, p+1, tid(rowcurr, colcurr-1), targetword, found, pathsofar, tid, row, col); // moving left
39 foo(board, p+1, tid(rowcurr+1, colcurr), targetword, found, pathsofar, tid, row, col); // moving down
40
41 // returning
42 return;
43 }
44
45
46 int main(){
47
48 // starting timer
49 Timer timer;
50
51 // setup
52 vector<vector<char>> board {
53     {'a','b','c'},
54     {'a','e','d'},
55     {'a','f','g'}
56 };
57
58

```

```

59 vector<string> words {"abcdefg", "gfedcbaaa", "eaabcdgfa", "befa", "dgc", "ade"};
60
61 // setup
62 std::function<int(const int&, const int&)> tid = [&board](const int row, const int col) {
63     if (row < 0 || row >= board.size() || col < 0 || col >= board[0].size()) {return std::numeric_limits<int>::max();}
64     return row* static_cast<int>(board[0].size()) + col ;
65 };
66 std::function<int(const int)> row = [&board](const int tid){
67     if (tid < 0 || tid > board.size() * board[0].size()) {return std::numeric_limits<int>::max();}
68     return tid/static_cast<int>(board[0].size());
69 };
70 std::function<int(const int)> col = [&board](const int tid){
71     if (tid < 0 || tid > board.size() * board[0].size()) {return std::numeric_limits<int>::max();}
72     return tid%static_cast<int>(board[0].size());
73 };
74
75 // printing
76 vector<string> finaloutput;
77 for(const auto& targetword: words){
78
79     // flag for finding the word
80     bool found {false};
81
82     // launching from every coordinate
83     for(int i = 0; i<board.size() && found == false; ++i){
84         for(int j = 0; j<board[0].size() && found == false; ++j){
85             vector<int> pathsofar;
86             foo(board, 0, tid(i, j), targetword, found, pathsofar, tid, row, col);
87         }
88     }
89
90     // adding to final output
91     if (found) {finaloutput.push_back(targetword);}
92 }
93

```

```
94 // printing the final-output
95 PRINTSPACE
96 cout << format("finaloutput = {}\n", finaloutput);
97
98 // return
99 return(0);
100
101 }
```

---

## 213. House Robber II

You are a professional robber planning to rob houses along a street. Each house has a certain amount of money stashed. All houses at this place are arranged in a circle. That means the first house is the neighbor of the last one. Meanwhile, adjacent houses have a security system connected, and it will automatically contact the police if two adjacent houses were broken into on the same night.

Given an integer array `nums` representing the amount of money of each house, return the maximum amount of money you can rob tonight without alerting the police.

### Examples

#### 1. Example 1:

- Input: `nums = [2,3,2]`
- Output: 3
- Explanation: You cannot rob house 1 (money = 2) and then rob house 3 (money = 2), because they are adjacent houses.

#### 2. Example 2:

- Input: `nums = [1,2,3,1]`
- Output: 4
- Explanation: Rob house 1 (money = 1) and then rob house 3 (money = 3).
  - Total amount you can rob =  $1 + 3 = 4$ .

#### 3. Example 3:

- Input: `nums = [1,2,3]`
- Output: 3

## Constraints

- $1 \leq \text{nums.length} \leq 100$
- $0 \leq \text{nums}[i] \leq 1000$

## Code

---

```
1 int fRob1(std::vector<int> nums){
2
3     // setup
4     std::vector<int> dp{nums[0]};
5     int maxCandidate;
6
7     // building the dp-table
8     for(int i = 1; i<nums.size(); ++i){
9
10        // checking which max value to use
11        if (i > 1)    {maxCandidate = std::max(nums[i]+ dp[i-2], dp[i-1]);}
12        else        {maxCandidate = std::max(nums[i], dp[i-1]);}
13
14        // storing max-candidate
15        dp.push_back(maxCandidate);
16
17    }
18
19    // returning the mx-value
20    return dp[dp.size()-1];
21 }
22
23 int main(){
24
25     // starting timer
```

```

26     Timer timer;
27
28     // input- configuration
29     auto nums {vector<int>{1,2,3,1}};
30
31     // sending things back
32     if(nums.size()== 0) {cout << format("final-output = 0\n"); return 0;}
33     if(nums.size()== 1) {cout << format("final-output = {}\n", nums[0]); return 0;}
34
35     // setup
36     auto firstCandidate {fRob1(std::vector<int>(nums.begin(), nums.end()-1))};
37     auto secondCandidate {fRob1(std::vector<int>(nums.begin()+1, nums.end()))};
38
39     // returning value
40     auto finaloutput {std::max(std::max(firstCandidate, secondCandidate), nums[0])};
41     cout << format("final-output = {}\n", finaloutput);
42
43     // return
44     return(0);
45
46 }

```

---

## 216. Combination Sum III

Find all valid combinations of  $k$  numbers that sum up to  $n$  such that the following conditions are true:

- Only numbers 1 through 9 are used.
- Each number is used at most once.

Return a list of all possible valid combinations. The list must not contain the same combination twice, and the combinations may be returned in any order.

### Examples

#### 1. Example 1:

- Input:  $k = 3, n = 7$
- Output: `[[1,2,4]]`
- Explanation:
  - $1 + 2 + 4 = 7$
  - There are no other valid combinations.

#### 2. Example 2:

- Input:  $k = 3, n = 9$
- Output: `[[1,2,6],[1,3,5],[2,3,4]]`



- Explanation:
  - $1 + 2 + 6 = 9$
  - $1 + 3 + 5 = 9$
  - $2 + 3 + 4 = 9$
  - There are no other valid combinations.

### 3. Example 3:

- Input:  $k = 4, n = 1$
- Output: []
- Explanation: There are no valid combinations.
  - Using 4 different numbers in the range [1,9], the smallest sum we can get is  $1+2+3+4 = 10$  and since  $10 \neq 1$ , there are no valid combination.

## Constraints

- $2 \leq k \leq 9$
- $1 \leq n \leq 60$

## Code

---

```

1 void fTraverse(std::vector<int> numberPath, \
2               int target, \
3               int k, \
4               std::vector< std::vector<int> >& finalOutput){
5
6     // checking if length is too much
7     if (numberPath.size() > k) return;
```

```

8
9 // calculating sum so far
10 int sumsofar = std::accumulate(numberPath.begin(), numberPath.end(),0);
11
12 // number to fill
13 int sumtofill = target - sumsofar;
14
15 // if this is zero, we can add it to list and just sendn it back
16 if (sumtofill == 0){
17     if (numberPath.size() == k){
18         if (std::find(finalOutput.begin(),
19                     finalOutput.end(),
20                     numberPath) == finalOutput.end())
21             finalOutput.push_back(numberPath); // add if it doesn't already exist
22     }
23
24     return;
25 }
26
27 // valid candidates
28 std::vector<int> candidates;
29 int biggest_number = 1;
30 if (numberPath.size()!=0){
31     auto iter = std::max_element(numberPath.begin(), numberPath.end());
32     biggest_number = *iter;
33 }
34
35 sumtofill = std::min(sumtofill, 9);
36 for(int i = biggest_number; i<=sumtofill; ++i){
37     // add if no on th epath so far
38     if (std::find(numberPath.begin(),
39                 numberPath.end(),
40                 i) == numberPath.end()) {candidates.push_back(i);}
41 }
42

```

```

43 // if there are no candidates, we're going back
44 if (candidates.size() == 0) return;
45
46 // trying each candidate
47 std::vector<int> numberPath_local;
48 for(auto x: candidates){
49     // sending down each candidate route
50     numberPath_local = numberPath;
51     numberPath_local.push_back(x);
52     fTraverse(numberPath_local, target, k, finalOutput);
53 }
54
55 // returning
56 return;
57 }
58
59 int main(){
60
61     // starting timer
62     Timer timer;
63
64     // input- configuration
65     auto k {3};
66     auto n {7};
67
68     // setup
69     std::vector< std::vector<int> > finalOutput;
70     std::vector<int> numberPath;
71
72     // recursion
73     fTraverse(numberPath, n, k, finalOutput);
74
75     // printing
76     cout << format("final-output = {}\n", finalOutput);
77

```

```
78     // return
79     return(0);
80
81 }
```

---

## 219. Contains Duplicate II

Given an integer array `nums` and an integer `k`, return `true` if there are two distinct indices `i` and `j` in the array such that `nums[i] == nums[j]` and  $\text{abs}(i - j) \leq k$ .

### Examples

#### 1. Example 1:

- Input: `nums = [1,2,3,1]`, `k = 3`
- Output: `true`

#### 2. Example 2:

- Input: `nums = [1,0,1,1]`, `k = 1`
- Output: `true`

#### 3. Example 3:

- Input: `nums = [1,2,3,1,2,3]`, `k = 2`
- Output: `false`

### Constraints

- $1 \leq \text{nums.length} \leq 10^5$
- $-10^9 \leq \text{nums}[i] \leq 10^9$
- $0 \leq k \leq 10^5$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto nums = std::vector<int>({1,2,3,1,2,3});
8     auto k     {2};
9
10    // setup
11    std::unordered_map<int, int> valueToIndex;
12
13    // going through the array
14    for(int i = 0; i<nums.size(); ++i){
15
16        // adding current element to the hamp
17        if (valueToIndex.find(nums[i]) == valueToIndex.end()){
18            // if it doesn't exist, we add to it
19            valueToIndex[nums[i]] = i;
20        }
21        else{
22            // if it already exists, calculating distance from the first index
23            if (i - valueToIndex[nums[i]] <= k) {cout << format("final-output = true\n");}
24            else {valueToIndex[nums[i]] = i;}
25        }
26    }
27
28    // returning false in the final case
29    cout << format("final-output = false\n");
30
31    // return
32    return(0);
33}
```



## 226. Invert Binary Tree

Given the root of a binary tree, invert the tree, and return its root.

### Examples

1. **Example 1:**

- Input: root = [4,2,7,1,3,6,9]
- Output: [4,7,2,9,6,3,1]

2. **Example 2:**

- Input: root = [2,1,3]
- Output: [2,3,1]

3. **Example 3:**

- Input: root = []
- Output: []

### Constraints

- The number of nodes in the tree is in the range [0, 100].
- $-100 \leq \text{Node.val} \leq 100$



## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto root      {new TreeNode(4)};
8     root->left      = new TreeNode(2);
9     root->right     = new TreeNode(7);
10    root->left->left  = new TreeNode(1);
11    root->left->right = new TreeNode(3);
12    root->right->left = new TreeNode(6);
13    root->right->right = new TreeNode(9);
14
15    // setup
16    std::function<void(TreeNode*)> fTwist = [&fTwist](TreeNode* root){
17        // base-case
18        if (root == nullptr) return;
19
20        // switching left and right
21        fTwist(root->left);
22        fTwist(root->right);
23
24        // twisting current branches
25        auto temp = root->left;
26        root->left = root->right;
27        root->right = temp;
28
29        // returning
30        return;
31    };
32
33    // going flipping through everyrthing
```

```
34     fTwist(root);  
35  
36     // return  
37     return(0);  
38  
39 }
```

---

## 228. Summary Ranges

You are given a sorted unique integer array `nums`.

A range `[a,b]` is the set of all integers from `a` to `b` (inclusive).

Return the smallest sorted list of ranges that cover all the numbers in the array exactly. That is, each element of `nums` is covered by exactly one of the ranges, and there is no integer `x` such that `x` is in one of the ranges but not in `nums`.

Each range `[a,b]` in the list should be output as:

"a→b" if `a != b`

"a" if `a == b`

### Examples

#### 1. Example 1:

- Input: `nums = [0,1,2,4,5,7]`
- Output: `["0→2","4→5","7"]`
- Explanation: The ranges are:
  - `[0,2] ⇒ "0→2"`
  - `[4,5] ⇒ "4→5"`
  - `[7,7] ⇒ "7"`

#### 2. Example 2:

- Input: `nums = [0,2,3,4,6,8,9]`
- Output: `["0","2→4","6","8→9"]`

- Explanation: The ranges are:
  - $[0,0] \implies "0"$
  - $[2,4] \implies "2 \rightarrow 4"$
  - $[6,6] \implies "6"$
  - $[8,9] \implies "8 \rightarrow 9"$

## Constraints

- $0 \leq \text{nums.length} \leq 20$
- $-2^31 \leq \text{nums}[i] \leq 2^31 - 1$
- All the values of nums are unique.
- nums is sorted in ascending order.

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto nums = vector<int>({0,1,2,4,5,7});
8
9     // trivial-case
10    if (nums.size() == 0) {cout << format("final-output = {}\n", vector<string>()); return 0;}
11
12    // stup
```

```

13 auto arrow {"->"};
14 auto p1    {0};
15 auto p2    {0};
16 vector<string> finalOutput;
17
18 // while loop
19 while (p2<nums.size()){
20
21     // checking prev element
22     if (nums[p2] <= 1 + nums[p2-1]) {++p2;}
23     else{
24         if (p1!=p2-1) {finalOutput.push_back(std::to_string(nums[p1]) + arrow + std::to_string(nums[p2-1]));}
25         else          {finalOutput.push_back(std::to_string(nums[p2-1]));}
26         p1 = p2++;
27     }
28 }
29
30 // checking if p1 and p2 areright ne
31 if (p1!=p2-1) {finalOutput.push_back(std::to_string(nums[p1]) + arrow + std::to_string(nums[p2-1]));}
32 else          {finalOutput.push_back(std::to_string(nums[p2-1]));}
33
34 // returning restul
35 cout << format("final-output = {}\n", finalOutput);
36
37 // return
38 return(0);
39
40 }

```

---

## 230. Kth Smallest Element in a BST

Given the root of a binary search tree, and an integer k, return the kth smallest value (1-indexed) of all the values of the nodes in the tree.

### Examples

1. **Example 1:**

- Input: root = [3,1,4,null,2], k = 1
- Output: 1

2. **Example 2:**

- Input: root = [5,3,6,2,4,null,null,1], k = 3
- Output: 3

### Constraints

- The number of nodes in the tree is n.
- $1 \leq k \leq n \leq 10^4$
- $0 \leq \text{Node.val} \leq$

## Code

---

```
1 void foo(const TreeNode* root,
2         int& leftindex,
3         int& finalOutput,
4         bool& stopsearch,
5         const int k)
6 {
7     // sending it back
8     if (root == nullptr) return;
9
10    // checking left
11    foo(root->left, leftindex, finalOutput, stopsearch, k);
12
13    // appending count
14    ++leftindex;
15    if (leftindex == k){
16
17        finalOutput = root->val;
18        stopsearch = true;
19
20    }
21
22    // going right
23    foo(root->right, leftindex, finalOutput, stopsearch, k);
24
25    // goign back
26    return;
27 }
28
29 int main(){
30
31    // starting timer
32    Timer timer;
33
```

```

34 // input- configuration
35 auto root      {new TreeNode(3)};
36 root->left     = new TreeNode(1);
37 root->right    = new TreeNode(4);
38 root->left->right = new TreeNode(2);
39
40 auto k {1};
41
42 // setup
43 auto finalOutput {-1};
44 auto stopsearch  {false};
45 auto leftindex   {0};
46
47 // running the search
48 foo(root, leftindex, finalOutput, stopsearch, k);
49
50 // printing otuput
51 cout << format("final-output = {}\n", finalOutput);
52
53 // return
54 return(0);
55
56 }

```

---



## 235. Lowest Common Ancestor of a Binary Search Tree

Given a binary search tree (BST), find the lowest common ancestor (LCA) node of two given nodes in the BST.

According to the definition of LCA on Wikipedia: “The lowest common ancestor is defined between two nodes  $p$  and  $q$  as the lowest node in  $T$  that has both  $p$  and  $q$  as descendants (where we allow a node to be a descendant of itself).”

### Examples

#### 1. Example 1:

- Input: root = [6,2,8,0,4,7,9,null,null,3,5],  $p = 2$ ,  $q = 8$
- Output: 6
- Explanation: The LCA of nodes 2 and 8 is 6.

#### 2. Example 2:

- Input: root = [6,2,8,0,4,7,9,null,null,3,5],  $p = 2$ ,  $q = 4$
- Output: 2
- Explanation: The LCA of nodes 2 and 4 is 2, since a node can be a descendant of itself according to the LCA definition.

#### 3. Example 3:

- Input: root = [2,1],  $p = 2$ ,  $q = 1$
- Output: 2

## Constraints

- The number of nodes in the tree is in the range  $[2, 10^5]$ .
- $-10^9 \leq \text{Node.val} \leq 10^9$
- All `Node.val` are unique.
- $p \neq q$
- `p` and `q` will exist in the BST.

## Code

---

```
1 void foo(const TreeNode*    root,
2         const int          smallervalue,
3         const int          largervalue,
4         TreeNode*&          finalanswer){
5
6     if (root== nullptr)      return;
7     if (finalanswer != nullptr) return;
8
9     // checking current value
10    if (smallervalue <= root->val && root->val <= largervalue) {finalanswer = root;}
11    else if (root->val < smallervalue) {foo(root->right, smallervalue, largervalue, finalanswer);}
12    else if (root->val > largervalue) {foo(root->left,  smallervalue, largervalue, finalanswer);}
13
14    // returnring
15    return;
16 }
17
18 int main(){
19
```

```

20 // starting timer
21 Timer timer;
22
23 // input- configuration
24 auto root {new TreeNode(6)};
25
26 root->left    = new TreeNode(2);
27 root->right   = new TreeNode(8);
28
29 root->left->left = new TreeNode(0);
30 root->left->right = new TreeNode(4);
31 root->right->left = new TreeNode(7);
32 root->right->right = new TreeNode(9);
33
34 root->left->right->left = new TreeNode(3);
35 root->left->right->right = new TreeNode(5);
36
37 auto p    {root->left};
38 auto q    {root->right};
39
40 // setup
41 const auto smallvalue {std::min(p->val, q->val)};
42 const auto largervalue {std::max(p->val, q->val)};
43 auto      finalanswer  {static_cast<TreeNode*>(nullptr)};
44
45 //calling the function
46 foo(root, smallvalue, largervalue, finalanswer);
47
48 // returning the final answer
49 cout << format("final-output = {}\n", finalanswer->val);
50
51 // return
52 return(0);
53
54 }

```

## 238. Product of Array Except Self

Given an integer array `nums`, return an array `answer` such that `answer[i]` is equal to the product of all the elements of `nums` except `nums[i]`. The product of any prefix or suffix of `nums` is guaranteed to fit in a 32-bit integer. You must write an algorithm that runs in  $O(n)$  time and without using the division operation.

### Examples

#### 1. Example 1

- Input: `nums = [1,2,3,4]`
- Output: `[24,12,8,6]`

#### 2. Example 2

- Input: `nums = [-1,1,0,-3,3]`
- Output: `[0,0,9,0,0]`

### Constraints

1.  $2 \leq \text{nums.length} \leq 10^5$
2.  $-30 \leq \text{nums}[i] \leq 30$
3. The input is generated such that `answer[i]` is guaranteed to fit in a 32-bit integer

## Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> nums {1,2,3,4};
5
6     // setup
7     vector<int> nums_left(nums.size(), 1);
8     vector<int> nums_right(nums.size(), 1);
9     int acc_left {1};
10    int acc_right {1};
11
12    // runs
13    for(int i = 0; i<nums.size(); ++i){
14
15        // source-indices
16        int source_left {i-1};
17        int source_right {static_cast<int>(nums.size())-i};
18
19        // printing values
20        acc_left  *= source_left == -1      ? 1 : nums[source_left];
21        acc_right *= source_right == nums.size() ? 1 : nums[source_right];
22
23        // writing to the two values
24        nums_left[i] = acc_left;
25        nums_right[nums.size()-i-1] = acc_right;
26    }
27
28    // building the accumulated value
29    vector<int> finaloutput(nums.size(),1);
30    for(int i = 0; i< finaloutput.size(); ++i){
31        finaloutput[i] = nums_left[i] * nums_right[i];
32    }
33}
```

```
34 // printing
35 cout << format("finaloutput = "); fPrintVector(finaloutput);
36
37 // return
38 return(0);
39
40 }
```

---

## 242. Valid Anagram

Given two strings  $s$  and  $t$ , return true if  $t$  is an anagram of  $s$ , and false otherwise.

### Examples

#### 1. Example 1:

- Input:  $s = \text{"anagram"}, t = \text{"nagaram"}$
- Output: true

#### 2. Example 2:

- Input:  $s = \text{"rat"}, t = \text{"car"}$
- Output: false

### Constraints

- $1 \leq s.length, t.length \leq 5 * 10^4$
- $s$  and  $t$  consist of lowercase English letters.

### Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     string s {"anagram"};
8     string t {"nagaram"};
9
10    // setup
11    std::vector<int> s_count(26,0);
12    std::vector<int> t_count(26,0);
13
14    // building count-vector for both
15    for(auto x: s) ++s_count[static_cast<int>(x)-97];
16    for(auto x: t) ++t_count[static_cast<int>(x)-97];
17
18    // comparing the two
19    for (int i = 0; i<s_count.size(); ++i) {
20
21        // element-wise checking
22        if (s_count[i] != t_count[i]) {cout << format("final-output = false \n");}
23
24    }
25
26    // returning
27    cout << format("final-output = true \n");
28
29    // return
30    return(0);
31
32 }
```

---



## 274. H-Index

Given an array of integers citations where citations[i] is the number of citations a researcher received for their ith paper, return the researcher's h-index. According to the definition of h-index on Wikipedia: The h-index is defined as the maximum value of h such that the given researcher has published at least h papers that have each been cited at least h times.

### Examples

#### 1. Example 1

- Input: citations = [3,0,6,1,5]
- Output: 3
- Explanation: [3,0,6,1,5] means the researcher has 5 papers in total and each of them had received 3, 0, 6, 1, 5 citations respectively. Since the researcher has 3 papers with at least 3 citations each and the remaining two with no more than 3 citations each, their h-index is 3.

#### 2. Example 2

- Input: citations = [1,3,1]
- Output: 1

### Constraints

1.  $n == \text{citations.length}$
2.  $1 \leq n \leq 5000$
3.  $0 \leq \text{citations}[i] \leq 1000$

## Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> citations {3,0,6,1,5};
5
6     // sorting the citations first
7     std::sort(citations.begin(), citations.end(),
8               [](const int& a, const int& b) {return a>b;});
9
10    // running accumulations
11    auto hvalue {0};
12    for(int i = 0; i<citations.size(); ++i){
13        if (citations[i] >= (i+1))    {hvalue = i+1;}
14    }
15
16    // printing citations
17    cout << format("hvalue = {}\n", hvalue);
18
19    // return
20    return(0);
21
22 }
```

---

## 283. Move Zeros

Given an integer array `nums`, move all 0's to the end of it while maintaining the relative order of the non-zero elements. Note that you must do this in-place without making a copy of the array.

### Examples

#### 1. Example 1:

- Input: `nums = [0,1,0,3,12]`
- Output: `[1,3,12,0,0]`

#### 2. Example 2:

- Input: `nums = [0]`
- Output: `[0]`

### Constraints:

- $1 \leq \text{nums.length} \leq 10^4$
- $-2^{31} \leq \text{nums}[i] \leq 2^{31} - 1$

### Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<int> nums {0,1,0,3,12};
5
6     // setup
7     int explorer {0};
8     int anchor {0};
9
10    // going through the nums
11    while(explorer < nums.size()){
12
13        // moving explorer until we arrive at a non-zero value
14        while(explorer < nums.size() && nums[explorer] == 0) {explorer++;}
15
16        // copying value
17        if (explorer<nums.size() && anchor <nums.size())
18            nums[anchor++] = nums[explorer++];
19    }
20
21    // zeroing out the rest
22    while(anchor < nums.size()) {nums[anchor++] = 0;}
23
24    // printing the finaloutput
25    cout << format("finaloutput = "); fPrintVector(nums);
26
27    // return
28    return(0);
29
30 }
```

---

## 300. Longest Increasing Subsequence

Given an integer array `nums`, return the length of the longest strictly increasing subsequence.

### Examples

#### 1. Example 1:

- Input: `nums = [10,9,2,5,3,7,101,18]`
- Output: 4
- Explanation: The longest increasing subsequence is `[2,3,7,101]`, therefore the length is 4.

#### 2. Example 2:

- Input: `nums = [0,1,0,3,2,3]`
- Output: 4

#### 3. Example 3:

- Input: `nums = [7,7,7,7,7,7,7]`
- Output: 1

### Constraints

- $1 \leq \text{nums.length} \leq 2500$
- $-10^4 \leq \text{nums}[i] \leq 10^4$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto nums {vector<int>{10,9,2,5,3,7,101,18}};
8
9     // finding number of elements
10    auto n {static_cast<int>(nums.size())};
11    std::vector<int> dp(n, 1);    // table to store the dynamic variables
12
13    // going through the arrays
14    for(int i = 0; i<n; ++i)
15        for(int j = 0; j<i; ++j)
16            if (nums[i] > nums[j]) {dp[i] = std::max(dp[i], dp[j]+1);}
17
18    // printing max-value
19    auto maxiter = std::max_element(dp.begin(), dp.end());
20    cout << format("final-output = {}\n", *maxiter);
21
22    // return
23    return(0);
24
25 }
```

---

## 345. Reverse Vowels Of A String

Given a string *s*, reverse only all the vowels in the string and return it. The vowels are 'a', 'e', 'i', 'o', and 'u', and they can appear in both lower and upper cases, more than once.

### Examples

#### 1. Example 1:

- Input: *s* = "IceCreAm"
- Output: "AceCreIm"
- Explanation: The vowels in *s* are ['I', 'e', 'e', 'A']. On reversing the vowels, *s* becomes "AceCreIm".

#### 2. Example 2:

- Input: *s* = "leetcode"
- Output: "leotcede"

### Constraints

- $1 \leq s.length \leq 3 * 10^5$
- *s* consist of printable ASCII characters.

## Code

---

```
1  int main(){
2
3      // input- configuration
4      string s  {"leetcode"};
5
6      // going through the string
7      string     vowels      {"aeiouAEIOU"};
8      vector<int> vowel_indices;
9      string     reversed_vowels;
10     string     finaloutput = s;
11
12     // going through the string
13     for(int i = 0; i<s.size(); ++i){
14         if (vowels.find(s[i]) != string::npos){
15             reversed_vowels+=s[i];
16             vowel_indices.push_back(i);
17         }
18     }
19
20     // refilling the indices
21     for(int i = 0; i<vowel_indices.size(); ++i){
22         finaloutput[vowel_indices[i]] = reversed_vowels[reversed_vowels.size()-1-i];
23     }
24
25     // printing the final output
26     cout << format("finaloutput = {}\n", finaloutput);
27
28     // return
29     return(0);
30
31 }
```

---



## 347. Top K Frequent Elements

Given an integer array `nums` and an integer `k`, return the `k` most frequent elements. You may return the answer in any order.

### Examples

1. **Example 1:**

- Input: `nums = [1,1,1,2,2,3]`, `k = 2`
- Output: `[1,2]`

2. **Example 2:**

- Input: `nums = [1]`, `k = 1`
- Output: `[1]`

3. **Example 3:**

- Input: `nums = [1,2,1,2,1,2,3,1,3,2]`, `k = 2`
- Output: `[1,2]`

### Constraints

- $1 \leq \text{nums.length} \leq 10^5$
- $-10^4 \leq \text{nums}[i] \leq 10^4$
- `k` is in the range `[1, the number of unique elements in the array]`.
- It is guaranteed that the answer is unique.

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto nums {vector<int>{4,1,-1,2,-1,2,3}};
8     auto k     {2};
9
10    // setup
11    unordered_map<int, int> hist;
12
13    // building histogram
14    for(const auto& num: nums){
15        if (hist.find(num) == hist.end()) {hist[num] = 1;}
16        else                               {++hist[num];}
17    }
18
19    // creating vector pair
20    vector<vector<int>> kv;
21    for(const auto& x: hist)      {kv.emplace_back(vector<int>{x.first, x.second});}
22
23    // building the sorting lambda
24    auto sortinglambda = [](const auto& a, const auto& b) {return a[1] > b[1];};
25
26    // since we want just the first k-elements, use partial sort
27    std::partial_sort(kv.begin(), kv.begin() + k, kv.end(), sortinglambda);
28
29    // building the final output
30    auto finaloutput {vector<int>{}};
31    for(int i = 0; i<k; ++i) {finaloutput.push_back(kv[i][0]);}
32
33    // printing the final output
```

```
34     cout << format("final-output = {}\n", finaloutput);
35
36     // return
37     return(0);
38 }
```

---

## 392. Is Subsequence

Given two strings  $s$  and  $t$ , return true if  $s$  is a subsequence of  $t$ , or false otherwise.

A subsequence of a string is a new string that is formed from the original string by deleting some (can be none) of the characters without disturbing the relative positions of the remaining characters. (i.e., "ace" is a subsequence of "abcde" while "aec" is not).

### Examples

#### 1. Example 1:

- Input:  $s = \text{"abc"}, t = \text{"ahbgdc"}$
- Output: true

#### 2. Example 2:

- Input:  $s = \text{"axc"}, t = \text{"ahbgdc"}$
- Output: false

### Constraints

- $0 \leq s.length \leq 100$
- $0 \leq t.length \leq 10^4$
- $s$  and  $t$  consist only of lowercase English letters.

## Code

---

```
1 int main(){
2
3     // input- configuration
4     string s    {"abc"};
5     string t    {"ahbgdc"};
6
7     // setup
8     int i = 0;
9
10    // going through the elements
11    for(auto x: t) if (x == s[i]) ++i;
12
13    // returning
14    cout << format("final-output = {}\n", static_cast<bool>(i == s.size())) ;
15
16
17    // return
18    return(0);
19
20 }
```

---

## 394. Decode String

Given an encoded string, return its decoded string.

The encoding rule is:  $k[\text{encoded\_string}]$ , where the `encoded_string` inside the square brackets is being repeated exactly  $k$  times. Note that  $k$  is guaranteed to be a positive integer.

You may assume that the input string is always valid; there are no extra white spaces, square brackets are well-formed, etc. Furthermore, you may assume that the original data does not contain any digits and that digits are only for those repeat numbers,  $k$ . For example, there will not be input like `3a` or `2[4]`.

The test cases are generated so that the length of the output will never exceed  $10^5$ .

### Examples

#### 1. Example 1:

- Input:  $s = "3[a]2[bc]"$
- Output: `"aaabcbc"`

#### 2. Example 2:

- Input:  $s = "3[a2[c]]"$
- Output: `"accaccacc"`

#### 3. Example 3:

- Input:  $s = "2[abc]3[cd]ef"$
- Output: `"abccabccddcdcdcd"`

## Constraints:

- $1 \leq s.length \leq 30$
- s consists of lowercase English letters, digits, and square brackets '['].
- s is guaranteed to be a valid input.
- All the integers in s are in the range [1, 300].

## Code

---

```
1 int main(){
2
3     // input- configuration
4     string s {"100[leetcode]"};
5
6     // running
7     std::stack<char> mystack;                // stack
8     string temp;                            // temporary string used for decoding
9     int repcount {1};                      // used for decoding
10
11     // going through the inputs
12     for(int i = 0; i<s.size(); ++i){
13
14         if(s[i] != '[') {mystack.push(s[i]);} // pushing characters to stack until we
15         // arrive at "]"
16         else{
17             temp = "";                        // initializing temporary string
18             while(mystack.top() != '[') {    // expanding mini-string until we arrive at
19                 temp = mystack.top() + temp;
20                 mystack.pop();
21             }
22         }
23     }
24 }
```

```

20     }
21
22     mystack.pop(); // removing "["
23
24     // calculating the repcount
25     string numberasstring = "";
26     while(mystack.size() != 0 &&
27           mystack.top() - '0' >= 0 && '9' - mystack.top() >= 0)
28     {
29         numberasstring = mystack.top() + numberasstring;
30         mystack.pop();
31     }
32     repcount = std::stoi(numberasstring);
33
34     // mini-decoding
35     int multitempsize = repcount * temp.size(); // calculating size after multiplication
36     for(int j = 0; j<multitempsize; ++j) { // filling up the stack with decoded content
37         mystack.push(temp[j%temp.size()]);
38     }
39 }
40 }
41
42 // creating the final output
43 string finaloutput;
44 while(mystack.size()){
45     finaloutput = mystack.top() + finaloutput;
46     mystack.pop();
47 }
48
49 // printing the final output
50 cout << format("finaloutput = {}\n", finaloutput);
51
52 // return
53 return(0);
54

```





## 433. Minimum Genetic Mutation

A gene string can be represented by an 8-character long string, with choices from 'A', 'C', 'G', and 'T'.

Suppose we need to investigate a mutation from a gene string `startGene` to a gene string `endGene` where one mutation is defined as one single character changed in the gene string.

For example, "AACCGGTT" → "AACCGGTA" is one mutation.

There is also a gene bank `bank` that records all the valid gene mutations. A gene must be in `bank` to make it a valid gene string.

Given the two gene strings `startGene` and `endGene` and the gene bank `bank`, return the minimum number of mutations needed to mutate from `startGene` to `endGene`. If there is no such a mutation, return -1.

Note that the starting point is assumed to be valid, so it might not be included in the bank.

### Examples

#### 1. Example 1:

- Input: `startGene` = "AACCGGTT", `endGene` = "AACCGGTA", `bank` = ["AACCGGTA"]
- Output: 1

#### 2. Example 2:

- Input: `startGene` = "AACCGGTT", `endGene` = "AAACGGTA", `bank` = ["AACCGGTA","AACCGCTA","AAACGGTA"]
- Output: 2

## Constraints

- $0 \leq \text{bank.length} \leq 10$
- $\text{startGene.length} == \text{endGene.length} == \text{bank}[i].\text{length} == 8$
- $\text{startGene}$ ,  $\text{endGene}$ , and  $\text{bank}[i]$  consist of only the characters ['A', 'C', 'G', 'T'].

## Code

---

```
1 void foo(unordered_map<string, vector<string>>& stringtoneighbours,
2         vector<string> pathsofar,
3         bool& foundpath,
4         string endGene,
5         int& finaloutput){
6
7     // checking if the top of the stack has valid neighbours
8     string top = pathsofar[pathsofar.size()-1];
9
10    // checking if the current one is the final output
11    if (top == endGene)
12        finaloutput = finaloutput < pathsofar.size() ? finaloutput : pathsofar.size();
13
14    // checking its possible next-states
15    auto nextnodes = stringtoneighbours[top];
16
17    // going depth-first
18    for(auto x: nextnodes){
19
20        // not considering if it is already in the path
21        if(std::find(pathsofar.begin(),
22                    pathsofar.end(),
23                    x) != pathsofar.end()) continue;
```

```

24
25     // updating path so far
26     auto pathsofar_temp = pathsofar;
27     pathsofar_temp.push_back(x);
28
29     // calling function do it
30     foo(stringtoneighbours, pathsofar_temp, foundpath, endGene, finaloutput);
31 }
32 }
33
34 // main-file =====
35 int main(){
36
37     // starting timer
38     Timer timer;
39
40     // input- configuration
41     string startGene      = "AACCGGTT";
42     string endGene        = "AACCGGTA";
43     vector<string> bank    = {"AACCGGTA"};
44
45     // setup
46     unordered_map<string, vector<string>> stringtoneighbours;
47
48     // checking if endgene is in the bank
49     if (std::find(bank.begin(),
50                 bank.end(),
51                 endGene) == bank.end()) {cout << format("finalOutput = -1\n");}
52
53     // going through the bank and building neighbours
54     bank.push_back(startGene);
55
56     for(auto x: bank){
57
58         // finding valid transactions with the other strings in the bank

```

```

59     for(auto y: bank){
60
61         // checking number of string differences between the two
62         auto count = 0;
63         for(int i =0; i<8; ++i) {if (x[i] != y[i]) ++count;}
64
65         // checking count and adding to valid transactions
66         if (count == 1)      {stringtoneighbours[x].push_back(y);}
67     }
68
69     // checking if this particular gene can jump to final gene
70     // checking number of string differences between the two
71     auto count = 0;
72     for(int i =0; i<8; ++i) {if (x[i] != endGene[i]) ++count;}
73
74     // checking count and adding to valid transactions
75     if (count == 1)      {stringtoneighbours[x].push_back(endGene);}
76 }
77
78 // recursion
79 vector<string> pathsofar {startGene};
80 bool          foundpath {false};
81 int           finalOutput {-1};
82
83 // calling the function
84 foo(stringtoneighbours, pathsofar, foundpath, endGene, finalOutput);
85
86 // returning the finaloutput
87 if (finalOutput > -1) --finalOutput;
88
89 // printing final output
90 cout << format("finalOutput = {}\n", finalOutput);
91
92 // return
93 return(0);

```

94

95

}

## 443. String Compression

Given an array of characters `chars`, compress it using the following algorithm:

Begin with an empty string `s`. For each group of consecutive repeating characters in `chars`:

1. If the group's length is 1, append the character to `s`.
2. Otherwise, append the character followed by the group's length.

The compressed string `s` should not be returned separately, but instead, be stored in the input character array `chars`. Note that group lengths that are 10 or longer will be split into multiple characters in `chars`. After you are done modifying the input array, return the new length of the array. You must write an algorithm that uses only constant extra space.

### Examples

#### 1. Example 1:

- Input: `chars = ["a","a","b","b","c","c","c"]`
- Output: Return 6, and the first 6 characters of the input array should be: `["a","2","b","2","c","3"]`
- Explanation: The groups are "aa", "bb", and "ccc". This compresses to "a2b2c3".

#### 2. Example 2:

- Input: `chars = ["a"]`
- Output: Return 1, and the first character of the input array should be: `["a"]`
- Explanation: The only group is "a", which remains uncompressed since it's a single character.

### 3. Example 3:

- Input: chars = ["a","b","b","b","b","b","b","b","b","b","b","b","b"]
- Output: Return 4, and the first 4 characters of the input array should be: ["a","b","1","2"].
- Explanation: The groups are "a" and "bbbbbbbbbbbb". This compresses to "ab12".

### Constraints

- $1 \leq \text{chars.length} \leq 2000$
- chars[i] is a lowercase English letter, uppercase English letter, digit, or symbol.

### Code

---

```
1 int main(){
2
3     // input- configuration
4     vector<char> chars {'a','b','b','b','b','b','b','b','b','b','b','b','b'};
5
6     // going through the character
7     int p1          {0};
8     char runningchar {};
9     char curr       {};
10    int count        {0};
11    string finaloutput;
12
13    // going through the inputs
14    while(p1<chars.size()){
15
16        // getting current tchar
```



```

17     curr = chars[p1];
18
19     // increasing count
20     if (count == 0)           {runningchar = chars[p1]; ++count;}
21     else if(curr == runningchar) {++count;}
22     else if(curr != runningchar) {
23         finaloutput += runningchar; // writing character to current pointer
24         if (count != 1)
25             finaloutput += std::to_string(count); // increasing write-pointer
26         runningchar = curr;
27         count = 1;
28     }
29
30     // increasing pointer
31     ++p1;
32 }
33
34 // flushing out
35 if (count != 0){
36     finaloutput += runningchar; // writing character to current pointer
37     if (count != 1)
38         finaloutput += std::to_string(count); // increasing write-pointer
39 }
40
41 // writing to input
42 for(int i = 0; i<finaloutput.size(); ++i){
43     chars[i] = finaloutput[i];
44 }
45
46 // printing the final output
47 cout << format("finaloutput = {}\n", finaloutput);
48 cout << "chars = "; fPrintVector(chars);
49 cout << format("return-value = {}\n", finaloutput.size());
50
51 // return

```

```
52     return(0);  
53  
54 }
```

---

## 530. Minimum Absolute Difference in BST

Given the root of a Binary Search Tree (BST), return the minimum absolute difference between the values of any two different nodes in the tree.

### Constraints

- The number of nodes in the tree is in the range  $[2, 10^4]$ .
- $0 \leq \text{Node.val} \leq 105$

### Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto root      {new TreeNode(4)};
8     root->left      = new TreeNode(2);
9     root->right      = new TreeNode(6);
10    root->left->left   = new TreeNode(1);
11    root->left->right  = new TreeNode(3);
12
13    // setup
14    vector<int> nodevalues;
15    std::function<void(const TreeNode*)> foo = [&foo, &nodevalues](
16        const TreeNode* root){
17        // returning
```

```

18     if (root == nullptr) return;
19
20     // going down left
21     if (root->left) {foo(root->left);}
22
23     // adding current-value
24     nodevalues.push_back(root->val);
25
26     // going down right
27     if (root->right) {foo(root->right);}
28
29     // returning
30     return;
31 };
32
33 // calling function
34 foo(root);
35
36 // moving through node values
37 auto minvalue {std::numeric_limits<int>::max()};
38 auto temp      {-1};
39 for(int i = 0; i<nodevalues.size()-1; ++i){
40     // checking difference
41     temp      = std::abs(nodevalues[i]- nodevalues[i+1]);
42     minvalue  = std::min(minvalue, temp);
43 }
44
45 // returning minvalue
46 cout << format("final-output = {}\n", minvalue);
47
48 // return
49 return(0);
50
51 }

```

---

## 572. Subtree of Another Tree

Given the roots of two binary trees `root` and `subRoot`, return `true` if there is a subtree of `root` with the same structure and node values of `subRoot` and `false` otherwise.

A subtree of a binary tree `tree` is a tree that consists of a node in `tree` and all of this node's descendants. The `tree` could also be considered as a subtree of itself.

### Constraints

- The number of nodes in the root tree is in the range  $[1, 2000]$ .
- The number of nodes in the `subRoot` tree is in the range  $[1, 1000]$ .
- $-10^4 \leq \text{root.val} \leq 10^4$
- $-10^4 \leq \text{subRoot.val} \leq 10^4$

### Code

---

```
1 bool fAreWeTheSame(TreeNode* root, TreeNode* subroot){
2
3     // checking if root-note values are the same
4     if (root == nullptr && subroot == nullptr) return true;
5     if (root == nullptr || subroot == nullptr) return false;
6     if (root->val != subroot->val) return false;
7
8     // going through the branches
9     auto isLeftBranchEqual {fAreWeTheSame(root->left, subroot->left)};
10    auto isRightBranchEqual {fAreWeTheSame(root->right, subroot->right)};
```

```

11
12 // returning
13 return (isLeftBranchEqual && isRightBranchEqual);
14 }
15
16 void f(TreeNode* root, TreeNode* subroot, bool& logicAccum){
17
18 // base-case
19 if (root == nullptr || subroot == nullptr) return;
20
21 // checking if they have the same head-value
22 if (root->val == subroot->val)
23     logicAccum = logicAccum || fAreWeTheSame(root, subroot);
24
25 // sending it back if we found one already
26 if (logicAccum) return;
27
28 // moving onto the next
29 f(root->left, subroot, logicAccum);
30 f(root->right, subroot, logicAccum);
31
32 // return
33 return;
34
35 }
36
37 int main(){
38
39 // starting timer
40 Timer timer;
41
42 // input- configuration
43 auto root {new TreeNode(3)};
44 root->left = new TreeNode(4);
45 root->right = new TreeNode(5);

```

```
46     root->left->left  = new TreeNode(1);
47     root->left->right = new TreeNode(2);
48
49     auto subRoot      {new TreeNode(4)};
50     subRoot->left      = new TreeNode(1);
51     subRoot->right     = new TreeNode(2);
52
53     // setup
54     bool logicAccum = false;
55     f(root, subRoot, logicAccum);
56
57     // printing output
58     cout << format("final-output = {}\n", logicAccum);
59
60     // return
61     return(0);
62
63 }
```

---

## 918. Maximum Sum Circular Subarray

Given a circular integer array `nums` of length `n`, return the maximum possible sum of a non-empty subarray of `nums`.

A circular array means the end of the array connects to the beginning of the array. Formally, the next element of `nums[i]` is `nums[(i + 1) % n]` and the previous element of `nums[i]` is `nums[(i - 1 + n) % n]`.

A subarray may only include each element of the fixed buffer `nums` at most once. Formally, for a subarray `nums[i]`, `nums[i + 1]`, ..., `nums[j]`, there does not exist  $i \leq k_1, k_2 \leq j$  with  $k_1 \% n \neq k_2 \% n$ .

### Examples

#### 1. Example 1:

- Input: `nums = [1,-2,3,-2]`
- Output: 3
- Explanation: Subarray `[3]` has maximum sum 3.

#### 2. Example 2:

- Input: `nums = [5,-3,5]`
- Output: 10
- Explanation: Subarray `[5,5]` has maximum sum  $5 + 5 = 10$ .

#### 3. Example 3:

- Input: `nums = [-3,-2,-3]`
- Output: -2
- Explanation: Subarray `[-2]` has maximum sum -2.



## Constraints

- $n == \text{nums.length}$
- $1 \leq n \leq 3 * 10^4$
- $-3 * 10^4 \leq \text{nums}[i] \leq 3 * 10^4$

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto nums = {vector<int>{1,-2,3,-2}};
8
9     // setup
10    int global_maximum = {nums[0]};
11    int global_minimum = {nums[0]};
12    int running_max = {0};
13    int running_min = {0};
14    int total = {0};
15
16    // going through the array
17    for(auto x: nums){
18
19        // calculating running maximum and minimum values
20        running_max = max(running_max + x, x);
21        running_min = min(running_min + x, x);
22
23        // running up the total value
```

```
24     total += x;
25
26     // updating global maximum and minumum values
27     global_maximum = max(global_maximum, running_max);
28     global_minimum = min(global_minimum, running_min);
29 }
30
31 // some condition
32 if (global_maximum > 0)
33     global_maximum = max(global_maximum, total - global_minimum);
34
35 // printing the maximum
36 cout << format("final-output = {}\n", global_maximum);
37
38 // return
39 return(0);
40
41 }
```

---

## 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.

### Examples

#### 1. Example 1:

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

#### 2. Example 2:

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

#### 3. Example 3:

- Input: `text1 = "abc"`, `text2 = "def"`
- Output: 0
- Explanation: There is no such common subsequence, so the result is 0.

## Constraints

- $1 \leq \text{text1.length}, \text{text2.length} \leq 1000$
- text1 and text2 consist of only lowercase English characters.

## Code

---

```
1 int main(){
2
3     // starting timer
4     Timer timer;
5
6     // input- configuration
7     auto text1      {string("bsbininm")};
8     auto text2      {string("jmjkbkjkjv")};
9
10    // setup
11    auto entryvalue  {-1};
12    vector<vector<int>> dptable;
13
14    // creating dp-table
15    for(int i = 0; i<text1.size()+1; ++i)
16        dptable.push_back(vector<int>(text2.size()+1, 0));
17
18    // filling dptable
19    for(int row = text1.size()-1; row>=0; --row){
20        for(int col = text2.size()-1; col >= 0; --col){
21
22            // checking if current-values are the same
23            if (text1[row] == text2[col]) {entryvalue = 1 + dptable[row+1][col+1];}
24            else {entryvalue = std::max(dptable[row+1][col], dptable[row][col+1]);}
25        }
```

```
26         // storing to dptable
27         dptable[row][col] = entryvalue;
28     }
29 }
30
31 // printing the dptable
32 cout << format("final-output = {}\n", dptable[0][0]);
33
34 // printing matrix
35 fPrintMatrix(dptable);
36
37 // return
38 return(0);
39
40
41 }
```

---