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# 1. Array

## Find duplicate in the array

### Problem

Given an array of integers, 1 ≤ a[i] ≤ *n* (*n* = size of array), some elements appear **twice** and others appear **once**.

Find all the elements that appear **twice** in this array.

Input:

[4,3,2,7,8,2,3,1]

Output:

[2,3]

### Reference

LEETCODE

### Approach

Since content is with-in array index range. We will use itself array as hashTable and when we found item first time we change sign to negative and if second time we get same negative it is duplicate. If data was not in-range we will use hashmap or set.

### Solution

public List<Integer> findDuplicates(int[] nums) {

List<Integer> list = new ArrayList<>();

for (int i = 0; i < nums.length; i++) {

int n=Math.abs(nums[i])-1;

if (nums[n] < 0) {

list.add(n+1);

} else {

nums[n] = -nums[n];

}

}

return list;

}

### Time and space complexity

Time - O(n)

Space – O(1).In space as list needed only for this question

## Find Single element in the array

### Problem

Given a **non-empty** array of integers, every element appears *twice* except for one. Find that single one.

**Note:**

Your algorithm should have a linear runtime complexity. Could you implement it without using extra memory?

**Example 1:**

**Input:** [2,2,1]

**Output:** 1

**Example 2:**

**Input:** [14,1,2,1,2]

**Output:** 14

### Reference

LEETCODE

### Approach

We can use xor. Xor of two same elements is 0. So we loop array and do xor after end of loop. We have single element in result.

### Solution

public int singleNumber(int[] nums) {

int res = nums[0];

for(int i=1; i<nums.length; i++){

res = res^nums[i];

}

return res;

}

### Time and space complexity

Time - O(n)

Space – O(1)

## Find Numbers with Even Number of Digits

### Problem

Given an array nums of integers, return how many of them contain an even number of digits.

Example 1:

Input: nums = [12,345,2,6,7896]

Output: 2

Explanation:

12 contains 2 digits (even number of digits).

345 contains 3 digits (odd number of digits).

2 contains 1 digit (odd number of digits).

6 contains 1 digit (odd number of digits).

7896 contains 4 digits (even number of digits).

Therefore only 12 and 7896 contain an even number of digits.

### Reference

LEETCODE, MATH

### Approach

Approach 1 - can be to iterate over loop and convert each number to String and then check length is even or odd.

Approach 2 - can be to iterate over loop and use Math.log10 method and then check result%2==0. if it is true it is ODD else EVEN.

### Solution

public int findNumbers(int[] nums) {

int c=0;

for(int i=0;i<nums.length;i++){

int result = (int)Math.log10(nums[i]);

if(result %2!=0){

c++;

}

}

return c;

}

### Time and space complexity

Time - O(n)

Space – O(1)

## Largest Number

### Problem

Given a list of non-negative integers, arrange them such that they form the largest number.

Example 1:

Input: [10,2]

Output: "210"

Example 2:

Input: [3,30,34,5,9]

Output: "9534330"

### Reference

Leetcode, sort, array

### Approach

We need to sort data smartly i.e. write comparator smartly. So, for two string like 3 and 34 to check which one should come first just contact both combo like – 334 and 343. Now we know number larger can be made if 34 comes first and 3 after that.

So, we use above logic and sort the array.

### Solution

public String largestNumber(int[] nums) {

String[] str = new String[nums.length];

for(int i=0;i<nums.length;i++){

str[i]=String.valueOf(nums[i]);

}

Arrays.sort(str,(o1,o2)->{

String s1=o1+o2;

String s2=o2+o1;

return s2.compareTo(s1);

});

if("0".equals(str[0])){

return str[0];

}

StringBuilder sb=new StringBuilder(nums.length);

for(String s:str){

sb.append(s);

}

return sb.toString();

}

### Time and space complexity

Time - O(nlogn)

## Search Insert Position (Binary Search)

### Problem

Given a sorted array 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 may assume no duplicates in the array.

Example 1:

Input: [1,3,5,6], 5

Output: 2

Example 2:

Input: [1,3,5,6], 2

Output: 1

### Reference

LEETCODE, BINARY-SEARCH, ARRAY

### Approach

Binary search is best algorithm to search in a sorted array. It takes o(logn) time.

1. set start=0 and end=length-1

2. Iterate till start<=end

3. get mid of (start+end)/2 and check if target is in left or right or in the middle.

4. If target<arr[mid] it means target is present in left. So update end=mid-1.

5. So, by this approach we are dividing the items to be searched to half every time.

In this particular problem if element does not exist. In such case start will tell the position of element where it should supposed to be. In classic binary search if item does not found we return -1

### Solution

public int searchInsert(int[] nums, int target) {

int start = 0;

int end = nums.length - 1;

int mid = 0;

while (start <= end) {

mid = (start + end) / 2;

if (nums[mid] == target) {

return mid;

} else if (nums[mid] < target) {

start = mid + 1;

} else {

end = mid - 1;

}

}

return start;

}

### Time and space complexity

O(logn)

O(1)

## Count Negative Numbers in a Sorted Matrix

### Problem

Given m \* n matrix grid which is sorted in non-increasing order both row-wise and column-wise.

Return the number of negative numbers in grid.

Example 1:

Input: grid = [[4,3,2,-1],[3,2,1,-1],[1,1,-1,-2],[-1,-1,-2,-3]]

Output: 8

Explanation: There are 8 negatives number in the matrix.

### Reference

LEETCODE, ARRAY-2D, BINARY-SEARCH

### Approach

We use binary search algorithm row by row and find center if it’s negative update end=center-1 else start=center+1

When loop terminates start will be the index of first negative. So, total negative in that row is row.length – start.

Since we also know that column is also decreasing so, for second row we update end to start-1.so, that we will apply binary search to only 0 to last positive number in previous row.

And we keep it doing till last row.

### Solution

public int countNegatives(int[][] grid)

{

int c = 0;

for (int i = 0, end = grid[i].length - 1; i < grid.length; i++) {

int start = 0;

while (start <= end) {

int mid = (start + end) / 2;

if (grid[i][mid] < 0) {

end = mid - 1;

} else {

start = mid + 1;

}

}

c = c + grid[i].length - start;

end = start - 1;

}

return c;

}

### Time and space complexity

Time - O(n+m)

Space - O(1)

## Move Zeroes to end of array

### Problem

Given an array nums, write a function to move all 0's to the end of it while maintaining the relative order of the non-zero elements.

Example:

Input: [0,1,0,3,12]

Output: [1,3,12,0,0]

### Reference

LEETCODE, ARRAY

### Approach

Here to make code generic we move val to the end of array.

We will keep count of val in c. and if c> 0 means we have at least one val. We move current element to i-c location. And update arr[i] to val.

It works because we make sure we are shifting non zero element to next available index on left.whic will be i-c.

If we does not have any zero we will not shift.

e.g. – 010004 -> in this case 1 will be shift to zero index .

i.e. 100004. Now c=1 and i=1. So, c keep on incrementing to 4. For i=5,arr[5-4]=arr[5] .

so,op will be 140000.

### Solution

public void searchAndShift(int[] arr, int val) {

int c = 0;

for (int i = 0; i < arr.length; i++) {

if (arr[i] == val) {

c++;

} else if (c > 0) {

arr[i - c] = arr[i];

arr[i] = val;

}

}

}

### Time and space complexity

Time - O(n)

Space – O(1)

## Two Sum

### Problem

Given an array of integers, return indices of the two numbers such that they add up to a specific target.

You may assume that each input would have exactly one solution, and you may not use the same element twice.

Example:

Given nums = [2, 7, 11, 15], target = 9,

Because nums[0] + nums[1] = 2 + 7 = 9,

return [0, 1].

### Reference

LEETCODE, ARRAY, HASHMAP

### Approach

Take hashmap and check if current item is in map if yes return else put (target-current item) in a loop.

### Solution

public int[] twoSum(int[] numbers, int target) {

Map<Integer, Integer> map = new HashMap<>();

for(int i = 0; i < numbers.length; i++) {

if(map.containsKey(numbers[i])) {

return new int[] {map.get(numbers[i]), i};

}

map.put(target - numbers[i], i);

}

return null;

}

### Time and space complexity

Time - O(n)

Space – O(n) (hashmap)

## Merge two sorted array

### Problem

Given two sorted integer arrays nums1 and nums2, merge nums2 into nums1 as one sorted array.

Note:

The number of elements initialized in nums1 and nums2 are m and n respectively.

You may assume that nums1 has enough space (size that is greater or equal to m + n) to hold additional elements from nums2.

Example:

Input:

nums1 = [1,2,3,0,0,0], m = 3

nums2 = [2,5,6], n = 3

Output: [1,2,2,3,5,6]

### Reference

LEETCODE, ARRAY

### Approach

Since we have empty places at end of nums1. We will start comparing from end i.e. from m-1 and n-1 and start filling larger element among two to the end of nums1. E.g. for 6 and 3 -> Output would for nums1=[1,2,3,0,0,6] and we decrement n only and we keep on doing it till the length of nums1 (not m).

### Solution

public void merge(int[] nums1, int m, int[] nums2, int n) {

int i = nums1.length - 1;

n--;

m--;

while (m >= 0 && n >= 0) {

if (nums1[m] > nums2[n]) {

nums1[i--] = nums1[m--];

} else {

nums1[i--] = nums2[n--];

}

}

while (n >= 0) {

nums1[i--] = nums2[n--];

}

}

### Time and space complexity

Time - O(nums1.length)

Space – O(1)

# 2. String

## Check if a string is substring of source. (Rabin Karp Algorithm)

### Problem

Check whether a given string is substring of source.

Example 1-

Input –

helloji,loj

Output –

True

### Reference

STRING, RABIN-KARP, ABDUL BARI

### Approach

Naive approach is to check character by character starting from i=0 and if not matched go back and now check for i=1.

Better approach -

It uses hashcode of a string and instead of matching character one by one.

\* We just match hashcode and once hashcode matched we check the content.

\* If not matched we subtract hashcode of first character and add hashcode of new character

\* It saves time of un-necessary comparison all the time.

\* But in worst case it might be possible that we might get hashcode same on every check.

\* To calculate hashcode again we just subtract hashcode of first character and add hashcode of next character in previous value.

\* For better performance make hash code function better to avoid un-necessary collision.

### Solution

int hSource = 0;

int hStr = 0;

//calculate hashcode of both source and string for first comparison

for (int i = 0; i < str.length(); i++) {

hSource = hSource + hashFunction(source.charAt(i));

hStr = hStr + hashFunction(str.charAt(i));

}

// we compare hash first and if matched return true.

// calculate hash again except for last value of i as we are generating hash in

// advanced.

for (int i = 0; i <= source.length() - str.length(); i++) {

if (hStr == hSource) {

int j = 0;

for (j = 0; j < str.length(); j++) {

if (source.charAt(j + i) != str.charAt(j)) {

break;

}

}

if (j == str.length()) {

return true;

}

}

//to avoid calculation after last index

if (i < source.length() - str.length()) {

hSource = hSource - hashFunction(source.charAt(i)) + hashFunction(source.charAt(i + str.length()));

}

}

return false;

### Time and space complexity

\* worst case - o(n\*m)

\* Best case - o(n+m)

## Anagram

### Problem

An anagram is a word formed by rearranging the letters of a different word. typically using all the original letters exactly once.

Given two strings s and t, write a function to determine if t is an anagram of s.

You may assume the string contains only lowercase alphabets.

Example 1:

Input: s = "anagram", t = "nagaram"

Output: true

Example 2:

Input: s = "rat", t = "car"

Output: false

### Reference

LEETCODE, ARRAY

### Approach

Take array with 26 size and from first string increment counter and for second decrement counter.

After loop finished iterate over table array and check if any non-zero value exists it’s not anagram.

### Solution

public boolean isAnagram(String s, String t) {

int[] table=new int[26];

if(s.length()!=t.length()){

return false;

}

for(int i=0;i<s.length();i++){

table[s.charAt(i)-'a']+=1;

table[t.charAt(i)-'a']-=1;

}

for(int i=0;i<table.length;i++){

if(table[i]!=0){

return false;

}

}

return true;

}

### Time and space complexity

Time - O(n+26)

Space – O(26) means constant

# 3. Math

## 1. Palindrome Number

### Problem

Determine whether an integer is a palindrome. An integer is a palindrome when it reads the same backward as forward.

Example 1:

Input: 121

Output: true

Example 2:

Input: -121

Output: false

Explanation: From left to right, it reads -121. From right to left, it becomes 121-

### Reference

LEETCODE, MATH, MOD

### Approach

Reverse the original number by adding remainder to the original number – res\*10+(num%10);

### Solution

public boolean isPalindrome(int num) {

int res = 0;

int num1 = num;

while (num > 0) {

res = res \* 10 + (num % 10);

num = num / 10;

}

return num1 == res;

}

### Time and space complexity

Time - o(n)

Space – o(1)

## 2. Happy Number

### Problem

Write an algorithm to determine if a number is "happy".

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

**Example:**

**Input:** 19

**Output:** true

**Explanation:**

12 + 92 = 82

82 + 22 = 68

62 + 82 = 100

12 + 02 + 02 = 1

### Reference

LEETCODE, MATH

### Approach

1. Loop infinite and find squareAndSum of n.

2. If n reach to 7 or 1. It means it is happy number as 7 will also resolve to 1.

3. Any other single number digit will never resolve to 1 or 7. and hence we return false in such case

### Solution

**public** **boolean** isHappy(**int** n) {

**if** (n < 1) {

**return** **false**;

}

**while** (**true**) {

n = squareAndSum(n);

**if** (n == 1 || n == 7)

**return** **true**;

**if** (n < 10)

**return** **false**;

}

}

**private** **int** squareAndSum(**int** n) {

**int** sum = 0;

**while** (n != 0) {

**int** rem = n % 10;

n = n / 10;

sum = sum + (rem \* rem);

}

**return** sum;

}

### Time and space complexity

Time -

Space – o(1)

# 4. Linked List

## 1. Reverse single linked list (Iterative + recursive)

### Problem

Reverse single linked list.

### Reference

SINGLE LINKED LIST, LEETCODE

### Approach

1. It can be done using three pointers. One to hold the current node,one with prev and one next node
2. Start by setting prev=null and current=head.
3. Iterate till current is not null and for every iteration set next = current.next and now set current.next=prev
4. And after that update prev to current and current to next.
5. After loop terminates current is the head of revsered list

### Solution

public void reverse() {

Node<T> prev = null;

while (head != null) {

Node<T> next = head.getNext();

head.setNext(prev);

prev = head;

head = next;

}

head = prev;

}

**public** Node<Integer> reverseListRecursive(Node<Integer> head) {

**return** reverseRecursive(head,**null**);

}

**private** Node<Integer> reverseRecursive(Node<Integer> head,Node<Integer> prev){

**if**(head==**null**){

**return** prev;

}

Node<Integer> next=head.getNext();

head.setNext(prev);

**return** reverseRecursive(next,head);

}

### Time and space complexity

Time - o(n)

Space – o(1) for iterative and o(n) for recursive

## Reverse single linked list recursive

### Problem

Reverse single linked list.

### Reference

SINGLE LINKED LIST, LEETCODE

### Approach

1. Call method till we reach last node. It will return last node
2. After that the head is second last node.
3. So, set last node next as second last.
4. Set second last node next as null. Otherwise it will form cycle.
5. Since in first call we will last node which will be new head. So, we return same node p from every call.

### Solution

**public** Node<Integer> reverseListRecursive(Node<Integer> head) {

// for last node return head.

**if** (head == **null** || head.getNext() == **null**) {

**return** head;

}

// call method till last node

Node<Integer> p = *reverseListRecursive*(head.getNext());

// after above call stack end we will receive last node in p

// and at present head is second last node

// set last node next as second last

head.getNext().setNext(head);

// set head next null

head.setNext(**null**);

// return last node, As we are returning same p again and again. we will receive last node only.

**return** p;

}

### Time and space complexity

Time - o(n)

Space – o(n)

## Check Palindrome single linked list

### Problem

Check if given single linked list is palindrome.

### Reference

SINGLE LINKED LIST, LEETCODE

### Approach

1. It can be done iteratively and recursively.
2. In **Iterative solution**->
   1. First find the middle of the linked list. After that set middle.next as null. So that we have now two linked list.
   2. Reverse one of the linked list and now compare one by one both linked list and if item different list is not palindrome.
3. In **Recursive solution->**
   1. take global variable left to hold the start side of the list and then call method recursively to reach the last element of the list and now compare if left item is equal to last item if yes return true else return false.
   2. Break the recursion if false is received or left reached end.

### Solution

**Iterative** –

public static boolean checkPalindromeIterative(Node<Integer> head) {

if (head == null || head.getNext() == null) {

return true;

}

// step1 find middle of the linked list

Node<Integer> middle = findMiddle(head);

// step2 partition the list into two halves- right and head

Node<Integer> right = middle.getNext();

middle.setNext(null);

// reverse one half

right = reverse(right);

//iterate with smaller half not null. in this way we ignore middle odd element if present.

while (right != null) {

if (head.getData() != right.getData()) {

return false;

}

head = head.getNext();

right = right.getNext();

}

return true;

}

private static Node<Integer> reverse(Node<Integer> head) {

Node<Integer> prev = null;

while (head != null) {

Node<Integer> next = head.getNext();

head.setNext(prev);

prev = head;

head = next;

}

return prev;

}

public static Node<Integer> findMiddle(Node<Integer> head) {

if (head == null) {

return head;

}

Node<Integer> fast = head;

Node<Integer> slow = head;

while (fast.getNext() != null && fast.getNext().getNext() != null) {

fast = fast.getNext().getNext();

slow = slow.getNext();

}

return slow;

}

**Recursive** –

private Node<T> left=head;

private boolean checkPalindrome(Node<T> node) {

if (left == null || node == null) {

return true;

}

boolean res = checkPalindrome(node.getNext());

if (res && left.getData().equals(node.getData())) {

left = left.getNext();

return true;

}

return false;

}

### Time and space complexity

Time - o(n)

Space – o(1)

## 4. Find middle element of single linked list

### Problem

Middle element of single linked list.

Input: [1,2,3,4,5,6]

Output: 3

### Reference

SINGLE LINKED LIST, LEETCODE

### Approach

1. Take two pointers one run at double speed and other single.
2. Once fast pointer reaches null. At that point slow will be in the middle.
3. If we want to return 4 in above code use below code –

Node<Integer> fast = head;

Node<Integer> slow = head;

while (fast!= null && fast.getNext()!= null) {

slow = slow.getNext();

fast = fast.getNext().getNext();

}

return slow;

### Solution

public static Node<Integer> findMiddleOfLinkedList(Node<Integer> head) {

if (head == null) {

return head;

}

Node<Integer> fast = head;

Node<Integer> slow = head;

while (fast.getNext() != null && fast.getNext().getNext() != null) {

slow = slow.getNext();

fast = fast.getNext().getNext();

}

return slow;

}

### Time and space complexity

Time - o(n)

Space – o(1)

## 5. Detect cycle in linked list

### Problem

Check if cycle exists in single linked list.

Input:



Output:

true

### Reference

SINGLE LINKED LIST, LEETCODE

### Approach

1. Take two pointers one run at double speed and other single.
2. If at any point they meet-> there is a cycle. And if node reaches null value. No cycle.

### Solution

public boolean hasCycle(Node<Integer> head) {

Node<Integer> slow = head;

Node<Integer> fast = head;

while (fast != null && fast.getNext() != null) {

slow = slow.getNext();

fast = fast.getNext().getNext();

if (slow == fast) {

return true;

}

}

return false;

}

### Time and space complexity

Time - o(n)

Space – o(1)

## 6. Detect cycle in linked list and return starting node of loop

### Problem

Check if cycle exists in single linked list. If loop is present then it returns point to first node of loop. Else it returns NULL.



### Reference

SINGLE LINKED LIST, LEETCODE, GEEKSFORGEEKS

### Approach

1. Take two pointers one run at double speed and other single.
2. If at any point they meet-> there is a cycle. And if node reaches null value. No cycle.
3. If cycle exists set any of the two pointer to head and now loop till both of them meets again. That meeting point is cycle starting point.

### Solution

public static Node<Integer> detectCycle(Node<Integer> head) {

Node<Integer> slow = head;

Node<Integer> fast = head.getNext();

while (fast != null && fast.getNext() != null) {

slow = slow.getNext();

fast = fast.getNext().getNext();

if (slow == fast) {

slow=head;

while(slow!=fast) {

slow=slow.getNext();

fast=fast.getNext();

}

return fast;

}

}

return null;

}

### Time and space complexity

Time - o(n)

Space – o(1)

## 7. Intersection of Two Linked Lists

### Problem

Write a program to find the node at which the intersection of two singly linked lists begins.

For example, the following two linked lists:



Begin to intersect at node 8.

### Reference

SINGLE LINKED LIST, LEETCODE

### Approach

* Get count of the nodes in the first list, let count be c1.
* Get count of the nodes in the second list, let count be c2.
* Get the difference of counts d = abs(c1 – c2)
* Now traverse the bigger list from the first node till d nodes so that from here onwards both the lists have equal no of nodes.
* Then we can traverse both the lists in parallel till we come across a common node. (Note that getting a common node is done by comparing the address of the nodes)

### Solution

public Node<Integer> getIntersectionNode(Node<Integer> headA, Node<Integer> headB) {

int lenA = getLength(headA);

int lenB = getLength(headB);

Node<Integer> first = null;

Node<Integer> second = null;

int diff = 0;

if (lenA > lenB) {

first = headA;

second = headB;

diff = lenA - lenB;

} else {

first = headB;

second = headA;

diff = lenB - lenA;

}

for (int i = 0; i < diff; i++) {

first = first.getNext();

}

while (first != null && second != null) {

if (first == second) {

return first;

}

first = first.getNext();

second = second.getNext();

}

return null;

}

public int getLength(Node<Integer> temp) {

int len = 0;

while (temp != null) {

temp = temp.getNext();

len++;

}

return len;

}

### Time and space complexity

Time - o(n)

Space – o(1)

## 8. Delete Linked List Elements

### Problem

Write a program to remove all elements from a linked list of integers that have value ‘val’.

Example:

Input: 1->2->6->3->4->5->6, val = 6

Output: 1->2->3->4->5

### Reference

SINGLE LINKED LIST, LEETCODE

### Approach

1. First delete the head till val=head.val

2. Then take two pointer prev and curr.

3. If item match set prev.next=curr.next

### Solution

public ListNode removeElements(ListNode head, int val) {

while(head!=null && head.val==val){

head=head.next;

}

if(head==null){

return null;

}

ListNode prev = head;

ListNode temp = head.next;

while(temp!=null){

if(temp.val==val){

prev.next=temp.next;

}

else {

prev=prev.next;

}

temp=temp.next;

}

return head;

}

### Time and space complexity

Time - o(n)

Space – o(1)

## 9. Separate odd even nodes

### Problem

Given a singly linked list, group all odd nodes together followed by the even

nodes. Please note here we are talking about the node number and not the

value in the nodes.

Input: 2->1->3->5->6->4->7->NULL

Output: 2->3->6->7->1->5->4->NULL

### Reference

SINGLE LINKED LIST, LEETCODE

### Approach

1.hold odd and even node, now in loop first update odd node

odd.next=even.next and odd=even.next;

2.now if odd.next is null. that means we dont have anything to be append to even node. so set even.next=null

3.else there is element. so , set even.next=odd.next and even=even.next

4.once loop finishes we have two different nodes -> odd will be at end element of itself and headEven which we already stored earlier will be starting of even

5.so, set odd.next=headEven;

### Solution

public static Node<Integer> oddEvenList(Node<Integer> head) {

if (head == null || head.getNext() == null || head.getNext().getNext() == null) {

return head;

}

Node<Integer> odd = head;

Node<Integer> even = head.getNext();

Node<Integer> evenHead = even;

while(even!=null && even.getNext()!=null) {

odd.setNext(even.getNext());

odd=odd.getNext();

if(odd.getNext()==null) {

even.setNext(null);

} else {

even.setNext(odd.getNext());

even=even.getNext();

}

}

odd.setNext(evenHead);

return head;

}

### Time and space complexity

Time - o(n)

Space – o(1)

## 10. Remove Nth Node From End of List

### Problem

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

**Example:**

Given linked list: **1->2->3->4->5**, and **n = 2**.

After removing the second node from the end, the linked list becomes **1->2->3->5**.

**Note:**

Given n will always be valid.

### Reference

SINGLE LINKED LIST, LEETCODE

### Approach

Instead of calculating length first and then perform len-n. we can do it in one pass by first moving till n. now start another pointer from head and move it till first pointer reaches end. At that point second pointer will be at nth position.

1. move curr to the nth node.
2. Curr2=head
3. Now start again till curr become null. and keep on incrementing curr2.
4. Now curr2.next is the node which we want to delete.

### Solution

public Node<Integer> removeNthFromEnd(Node<Integer> head, int n) {

Node<Integer> curr = head;

for (int i = 0; i < n; i++) {

curr = curr.getNext();

}

if (curr == null) {

return head.getNext();

}

Node<Integer> curr2 = head;

while (curr.getNext() != null) {

curr2 = curr2.getNext();

curr = curr.getNext();

}

curr2.setNext(curr2.getNext().getNext());

return head;

}

### Time and space complexity

Time - o(n)

Space – o(1)

## 11. Rotate List

### Problem

Given a linked list, rotate the list to the right by k places, where k is non-negative.

**Example 1:**

**Input:** 1->2->3->4->5->NULL, k = 2

**Output:** 4->5->1->2->3->NULL

**Explanation:**

rotate 1 steps to the right: 5->1->2->3->4->NULL

rotate 2 steps to the right: 4->5->1->2->3->NULL

**Example 2:**

**Input:** 0->1->2->NULL, k = 4

**Output:** 2->0->1->NULL

**Explanation:**

rotate 1 steps to the right: 2->0->1->NULL

rotate 2 steps to the right: 1->2->0->NULL

rotate 3 steps to the right: 0->1->2->NULL

rotate 4 steps to the right: 2->0->1->NULL

### Reference

SINGLE LINKED LIST, LEETCODE

### Approach

1. Calculate length of list and in same loop store last node also

2. To avoid cycle use k=k%length. If k=0 it means nothing to do just return head.

3. Just go to till length-k and now we know we need to break from here and store newHead. make last.next=newHead;

4.return newHead.

### Solution

public Node<Integer> rotateRight(Node<Integer> head, int k) {

if (head == null || head.getNext() == null || k == 0) {

return head;

}

//find length

int len = 1;

Node<Integer> last = head;

while (last.getNext() != null) {

last = last.getNext();

len++;

}

k = k % len;

if (k == 0) {

return head;

}

//update k = len - k

k = len - k;

Node<Integer> temp = head;

//goto till k. i.e. break point

for (int i = 1; i < k; i++) {

temp = temp.getNext();

}

Node<Integer> newHead = temp.getNext();

temp.setNext(null);

last.setNext(head);

return newHead;

}

### Time and space complexity

Time - o(n)

Space – o(1)

## 12. Swap Nodes in Pairs Recursive

### Problem

Given a linked list, swap every two adjacent nodes and return its head.

You may **not** modify the values in the list's nodes, only nodes itself may be changed.

**Example:**

Given 1->2->3->4, you should return the list as 2->1->4->3.

### Reference

SINGLE LINKED LIST, LEETCODE

### Approach

1. We will take head, head.next and head.next.next in head, second, third variable.
2. Set second.next as head. And we will set head.next as second of next recursive call.
3. Basically we will return second of next recursive call which will take third as argument.

### Solution

**public** **static** Node<Integer> swapPairsRecursive(Node<Integer> head) {

**if** (head == **null** || head.getNext() == **null**) {

**return** head;

}

Node<Integer> second = head.getNext();

Node<Integer> third = second.getNext();

second.setNext(head);

head.setNext(*swapPairsRecursive*(third));

**return** second;

}

### Time and space complexity

Time - o(n)

Space – o(n)

# 5. Stack

Follow LIFO order and push and pop operation take o(1) time.

## 1. Next greatest element in array

### Problem

Given an array, print the Next Greater Element (NGE) for every element. The Next greater Element for an element x is the first greater element on the right side of x in array. Elements for which no greater element exist, consider next greater element as -1.

For input array ->

{4, 5, 2, 25}

Element NGE

4 --> 5

5 --> 25

2 --> 25

25 --> -1

### Reference

SINGLE LINKED LIST, GEEKSFORGEEKS

### Approach

1. It can be done using two loops where we first find the element and after that next greatest element.

but it can be done in better way by using stack.

Algorithm -

1.if stack is empty push item into stack

2. else check if top element from stack < current array element.

3.if yes pop element. that current array element is the next greatest element of the popped element.

4.Keep popping from the stack while the popped element is smaller than next.

next becomes the next greater element for all such popped elements

5.Finally, push current element to the stack.

6.after the array is traversed completely the elements remained in the stack has -1 as next greatest element.

Since we wanted to return output array,we can store index of the element instead of actual element in stack.

and when we need to pop we uses it as a index of output to store the current element.

### Solution

public int[] nextGreatestElement(int[] arr) {

int n = arr.length;

int[] res = new int[n];

Deque<Integer> stack = new LinkedList<>();

//fill array with -1

for (int i = 0; i < n; i++) {

res[i] = -1;

}

for (int i = 0; i < n; i++) {

while (!stack.isEmpty() && arr[stack.peek()] < arr[i]) {

res[stack.pop()] = arr[i];

}

stack.push(i);

}

return res;

}

### Time and space complexity

Time - o(n)

Space – o(n)

If array is circular here then in above code loop till n\*2 and use i%n instead of i

for (int i = 0; i < n\*2; i++) {

while (!stack.isEmpty() && arr[stack.peek()] < arr[i%n]) {

res[stack.pop()] = arr[i%n];

}

stack.push(i%n);

}

## 2. Valid Parentheses

### Problem

Given a string 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.

Note that an empty string is also considered valid.

**Example 1:**

**Input:** "()"

**Output:** true

**Example 2:**

**Input:** "()[]{}"

**Output:** true

**Example 3:**

**Input:** "([)]"

**Output:** false

**Example 4:**

**Input:** "{[]}"

**Output:** true

### Reference

SINGLE LINKED LIST, LEETCODE

### Approach

1. It can be done using stack. we push ‘)‘ if current element is ‘(‘ and for ‘[‘ we push ‘]’ and for ‘{‘ we push ‘}’
2. If we have current item from ‘),},]’ we pop the element. if popped element is same as current item. It means we can continue else we return false.
3. During iteration if we know that stack is empty and we have received closed bracket as current element it means invalid also.
4. After loop finishes if stack is empty return true.

### Solution

public boolean isValid(String s) {

Deque<Character> stack = new LinkedList<>();

for(int i=0;i<s.length();i++) {

char ch=s.charAt(i);

if(ch=='('){

stack.push(')');

} else if(ch=='[') {

stack.push(']');

} else if(ch=='{') {

stack.push('}');

} else if(stack.isEmpty() || stack.pop()!=ch) {

return false;

}

}

return stack.isEmpty();

}

### Time and space complexity

Time - o(n)

Space – o(n)

## 3. Implement Queue using Stack

### Problem

Implement Queue using Stacks

### Reference

SINGLE LINKED LIST, LEETCODE

### Approach

1. It can be done using two stack.stack1 for addition and stack2 for removal

When we add element we push into stack1.

1. On removal we check if stack2 is empty add all elements from stack1 to stack2.

Return stack2.pop()

### Solution

private Deque<Integer> addS = new LinkedList<>();

private Deque<Integer> remS = new LinkedList<>();

/\*\* Push element x to the back of queue. \*/

public void push(int x) {

addS.push(x);

}

/\*\* Removes the element from in front of queue and returns that element. \*/

public int pop() {

if(remS.isEmpty()){

while(!addS.isEmpty()){

remS.push(addS.pop());

}

}

return remS.pop();

}

/\*\* Get the front element. \*/

public int peek() {

if(remS.isEmpty()){

while(!addS.isEmpty()){

remS.push(addS.pop());

}

}

return remS.peek();

}

/\*\* Returns whether the queue is empty. \*/

public boolean empty() {

return addS.isEmpty() && remS.isEmpty();

}

### Time and space complexity

Time - NA

Space – NA

## 4. Current Maximum element in stack

### Problem

Find maximum in a stack in O(1) time and O(1) extra space.

Given a Stack, keep track of the maximum value in it. The maximum value may be the top

element of the stack, but once a new element is pushed or an element is pop from the

stack, the maximum element will be now from the rest of the elements.

### Reference

SINGLE LINKED LIST, LEETCODE

### Approach

If two stacks are allowed – on add operation item will be added in both stacks. Stack1 will have original element and on stack2 we will current max.

For e.g –

Add 11

Stack1- 11

stack2 – 11

Add 2

Stack1- 11,2

stack2 – 11,11

add 3

Stack1- 11,2,3

stack2 – 11,11,11

add 40

Stack1- 11,2,3,40

stack2 – 11,11,11,40

So, on pop stack2 will give current max. and on pop we will remove from both the stacks.

**Without using extra stack i.e. O(1) –**

We will keep int max to store max element of the stack and instead of pushing item directly onto stack we follow –

**PUSH**

1. check if stack is empty. if yes add element and set max = newItem.

2. else

2.1. check if newItem x>max .if yes, push x+max to stack and update max=x. else push x in stack.

**POP**

Pop element x. if it is greater than max then return x-max else return max

**PEEK**

Peek from stack x. If it is > max return max else return x.

### Solution

public class StackMaxElementImproved {

private final Deque<Integer> stack = new Deque<>();

private int max = -1;

// o(1)

/\*\*

\*

\* @f:off

\* 1. check if stack is empty. if yes add element and set max = newItem.

\* 2. else

\* 2.1. check if newItem x>max .if yes, push x+max to stack and update max=x. else push x in stack.

\* @f:on

\*

\* @param data

\*/

public void push(int data) {

if (stack.isEmpty()) {

stack.push(data);

max = data;

} else {

if (max < data) {

stack.push(max + data);

max = data;

} else {

stack.push(data);

}

}

}

// o(1)

/\*\*

\*

\* @return get max element from stack

\*/

public int getMax() {

return max;

}

/\*\*

\* @f:off

\* 1. peek from stack. if y is greater than max -> return max.

\* else return y

\* @f:on

\* @return top element from stack

\*/

public int peek() {

if (stack.isEmpty()) {

return -1;

}

int item = stack.peek();

if (item > max) {

item = max;

}

return item;

}

// o(1)

/\*\*

\* 1. pop from stack. if y is greater than max -> set max=y-max and return old max.

\* else return y

\*

\* @return popped item

\*/

public int pop() {

if (stack.isEmpty()) {

return -1;

}

int item = stack.pop();

int res = item;

if (item > max) {

res = max;

max = item - max;

}

return res;

}

}

### Time and space complexity

Time – o(1) time for max

Space – o(1)

# 6. Queue

FIFO order, add and poll, peek methods take o(1) time

## 1. Implement Stack using queue

### Problem

Implement Stack using Queue.

### Reference

SINGLE LINKED LIST, LEETCODE

### Approach

1. It can be implemented using single queue.
2. logic is in push method only. In push method just move all the elements back to the queue except the newly

Inserted one. In this way pop and peek will return newly inserted element just like stack.

### Solution

public class StackUsingQueue {

private Queue<Integer> qa = new LinkedList<>();

/\*\* Push element x onto stack. \*/

public void push(int x) {

int n = qa.size();

qa.add(x);

while (n-- > 0) {

qa.add(qa.poll());

}

}

/\*\* Removes the element on top of the stack and returns that element. \*/

public int pop() {

return qa.poll();

}

/\*\* Get the top element. \*/

public int top() {

return qa.peek();

}

/\*\* Returns whether the stack is empty. \*/

public boolean empty() {

return qa.isEmpty();

}

}

### Time and space complexity

Time - o(n) for push, o(1) for pop and peek.

Space – one queue needed only.

# 7. Sorting

**Stable algorithm** - Stable sorting algorithms maintain the relative order of records with equal keys (i.e. values). That is, a sorting algorithm is stable if whenever there are two records R and S with the same key and with R appearing before S in the original list, R will appear before S in the sorted list.

**In-place algorithm** is an algorithm which transforms input using no auxiliary data structure. However a small amount of extra storage space is allowed for auxiliary variables.

An **adaptive algorithm** is an algorithm that changes its behavior at the time it is run, based on information available and on a priori defined reward mechanism. E.g. shell sort. It takes into consideration some part of data already sorted. and hence work faster on such cases where such type of chunk exists.

**HYBRID ALGORITHM** - it is combination of two or more sorting algorithm to take advantage of both Algorithm.

E.g. 1. *TIMSORT* - *insertion sort + merge sort.*

\* As Insertion sort is faster than both merge and quick sort if elements are small e.g. <10.

\* For large data set it uses merge sort. Collections.sort uses it as in case of linked list no extra memeory needed in merge operation.

E.g. 2. *INTROSORT* - *Quicksort + Heapsort.*

\* As bad pivot selection can lead to O(n^2) in quick sort worst case. it uses hybrid of both 1. Insertion sort in array

## 1. Insertion Sort in array

### Problem

Sort the given 1 dimension array using insertion sort.

### Reference

ARRAY, GEEKSFORGEEKS

### Approach

1. On small data set insertion sort, selection sort works better than merge or quick sort.
2. It is just like arranging cards.
3. Insertion sort requires more swap as compared to selection sort and hence is not preferred where write operation is costly. On other hand insertion sort is more efficient than bubble or selection as it speeds up when array is already partially sorted.
4. Insert ith element in between 0 to i-1 position where it needed to be present. In general Select an item and on the left of that item keep sorted data and on right keep on considering and place it in correct place on left.
5. In-place, Iterative, adaptive, stable.

### Solution

for (int i = 1; i < array.length; i++) {

for (int j = 0; j < i; j++) {

if (array[i]<array[j]) {

swap(array, i, j);

}

}

}

### Time and space complexity

Time - o(n^2)

Space – o(1)

## 2. Insertion Sort in Single Linked list

### Problem

Sort the given Single linked list using insertion sort.

### Reference

SINGLE LINKED LIST, LEETCODE, GEEKSFORGEEKS

### Approach

Here we will create a dummy list and start adding element to in it in sorted order.

1. curr node will point to current iteration element.

2. prev will point to previous node after which element will be needed to insert

3. dummy - use to hold the result modified sorted list.

Steps -

1. Start curr from head and set dummy as least integer and prev also.

2. If item to be inserted is greater then prev node. we need to start searching from start i.e. from dummy. so, set prev=dummy

3. Now loop till we find position of new item. i.e. where it is less then prev.next or prev.next is null.

In this way we now know after prev we can add that item as after that other elements are greater.

4. Now just add element between prev and prev.next

5. Update curr node to next element of the loop.

### Solution

public static Node<Integer> insertionSort(Node<Integer> head) {

Node<Integer> dummy = new Node<Integer>(Integer.MIN\_VALUE);

Node<Integer> curr = head;

Node<Integer> prev = dummy;

while (curr != null) {

// Store nextNode for next iteration

Node<Integer> nextNode = curr.getNext();

// to save checking from start- below condition is used

if (prev.getData() > curr.getData()) {

prev = dummy;

}

// go to a point where we need to insert new item starting from prev.

while (prev.getNext() != null && prev.getNext().getData() < curr.getData()) {

prev = prev.getNext();

}

// insert current node between prev and prev.next

curr.setNext(prev.getNext());

prev.setNext(curr);

curr = nextNode;

}

return dummy.getNext();

}

### Time and space complexity

Time - o(n^2)

Space – o(1)

## Selection Sort in array

### Problem

On a given array apply selection sort to sort the data.

### Reference

ARRAY, LEETCODE, GEEKSFORGEEKS

### Approach

1. In it we find min in array and swap it with 0 index and then start searching min again from 1 to n and now swap min with 1 and so on.

2. It is an in-place algorithm

### Solution

for (int i = 0; i < array.length; i++) {

int minIndex = i;

for (int j = i + 1; j < array.length; j++) {

if (array[j].compareTo(array[minIndex]) < 0) {

minIndex = j;

}

}

swap(array, i, minIndex);

}

### Time and space complexity

Time - O(n^2)

Space – O(1)

## Selection Sort in Single linked list

### Problem

On a given single linked list apply selection sort to sort the data.

### Reference

SINGLE LINKED LIST, GEEKSFORGEEKS

### Approach

1. In it we find min in Linked list and swap it with 0 index and then start searching min again from 1 to n and now swap min with 1 and so on.
2. For swapping we will swap content of the data not the node itself.

3. It is an in-place algorithm

### Solution

public static Node<Integer> selectionSort(Node<Integer> head) {

Node<Integer> temp = head;

while (temp != null) {

Node<Integer> minNode = temp;

Node<Integer> dummy = temp.getNext();

while (dummy != null) {

if (dummy.getData() < minNode.getData()) {

minNode=dummy;

}

dummy=dummy.getNext();

}

int data = minNode.getData();

minNode.setData(temp.getData());

temp.setData(data);

temp = temp.getNext();

}

return head;

}

### Time and space complexity

Time - O(n^2)

Space – O(1)

## Bubble Sort in array

### Problem

Apply bubble sort algorithm to sort the array.

### Reference

ARRAY

### Approach

1. Compare 0 element with 1 and arrange them. Then it take 1 element with 2 and arrange.

So after 1st iteration largest element moved to the end of array.

From next iteration onwards we will start from 0 and ignore last element as it is already in the correct position.

2. Stable, In-place

### Solution

for (int i = 0; i < array.length-1; i++) {

// if after entire below loop no swap happen then it means array is already sorted

boolean swap=false;

for (int j = 0; j < array.length - i -1; j++) {

if (array[j].compareTo(array[j+1]) > 0) {

swap(array, j, j+1);

swap=true;

}

}

//break as array is now sorted.

if(!swap) {

break;

}

}

### Time and space complexity

Time - O(n^2)

Space – O(1)

## Bubble Sort in Single Linked list

### Problem

Apply bubble sort algorithm to sort the linked list.

### Reference

SINGLE LINKED LIST

### Approach

1. Compare 0 element with 1 and arrange them. Then it take 1 element with 2 and arrange.

So after 1st iteration largest element moved to the end of array.

From next iteration onwards we will start from 0 and ignore last element as it is already in the correct position.

2. Stable, In-place

3. We will swap data instead of swapping nodes for simpler solution

### Solution

public static Node<Integer> bubbleSort(Node<Integer> head) {

Node<Integer> end = null;

while (end != head) {

Node<Integer> next = head;

while (next.getNext() != null && next.getNext() != end) {

if (next.getData() > next.getNext().getData()) {

int t = next.getData();

next.setData(next.getNext().getData());

next.getNext().setData(t);

}

next = next.getNext();

}

end = next;

}

return head;

}

### Time and space complexity

Time - O(n^2)

Space – O(1)

## Merge Sort in array

Merge sort has best and worst case both as nlogn. But it takes extra memory. On other hand quick sort has avg case nlogn but worst case n^2

### Problem

Apply merge sort algorithm to sort the array.

### Reference

ARRAY, GEEKSFORGEEKS

### Approach

1. divide and conquer strategy
2. It divides input array in two halves, calls itself for the two halves and then merges the two sorted halves. The merge() function is used for merging two halves.



2. Stable, take extra memory

### Solution

public static void mergeSort(int[] arr) {

mergeSort(arr, 0, arr.length - 1);

}

private static void mergeSort(int[] arr, int i, int j) {

if (i < j) {

int mid = (i + j) / 2;

mergeSort(arr, i, mid); // divide left sub array

mergeSort(arr, mid + 1, j); // divide right sub array

merge(arr, i, j, mid); // merge the two sorted array.

}

}

private static void merge(int[] arr, int l, int r, int mid) {

int[] temp = new int[r - l + 1];

int i = l;

int j = mid + 1;

int count = 0;

while (i <= mid && j <= r) {

if (arr[i] <= arr[j]) {

temp[count++] = arr[i++];

} else {

temp[count++] = arr[j++];

}

}

while (i <= mid) {

temp[count++] = arr[i++];

}

while (j <= r) {

temp[count++] = arr[j++];

}

for (int p = l; p <= r; p++) {

arr[p] = temp[p - l];

}

}

### Time and space complexity

Time - O(nlogn)

Space – O(n)

## 8. Merge Sort in linked list

Merge sort has best and worst case both as nlogn. It takes space O(logn) in linked list.

### Problem

Apply merge sort algorithm to sort the single linked list.

### Reference

ARRAY, LEETCODE

### Approach

1. divide and conquer strategy
2. It divides input array in two halves, calls itself for the two halves and then merges the two sorted halves. The merge() function is used for merging two halves.
3. So, basically we will find middle element of the list and detach middle.next

So, first half head will have data till middle and middleNext element will be the starting point of second list.

And then we merge them together (for merging we can use both iterative solution as well as recursive solution)

### Solution

public static Node<Integer> mergeSort(Node<Integer> head) {

if (head == null || head.getNext() == null) {

return head;

}

//find middle element

Node<Integer> middle = findMiddleOfLinkedList(head);

//point middleNext to the start of second half of list

Node<Integer> middleNext = middle.getNext();

//set end of first half to null. (for clear separation of two list)

middle.setNext(null);

//now call merge sort for first half

Node<Integer> left = mergeSort(head);

//call merge sort for second half

Node<Integer> right = mergeSort(middleNext);

// merge sorted list

return mergeSortedLists(left, right);

}

private static Node<Integer> mergeSortedLists(Node<Integer> first, Node<Integer> second) {

Node<Integer> dummy = new Node<>(Integer.MAX\_VALUE);

Node<Integer> head=dummy;

while (first != null && second != null) {

if (first.getData() <= second.getData()) {

dummy.setNext(first);

first = first.getNext();

} else {

dummy.setNext(second);

second = second.getNext();

}

dummy = dummy.getNext();

}

while (first != null) {

dummy.setNext(first);

first = first.getNext();

dummy = dummy.getNext();

}

while (second != null) {

dummy.setNext(second);

second = second.getNext();

dummy = dummy.getNext();

}

return head.getNext();

}

public static Node<Integer> findMiddleOfLinkedList(Node<Integer> head) {

if (head == null) {

return head;

}

Node<Integer> fast = head;

Node<Integer> slow = head;

while (fast.getNext() != null && fast.getNext().getNext() != null) {

slow = slow.getNext();

fast = fast.getNext().getNext();

}

return slow;

}

### Time and space complexity

Time - O(nlogn)

Space – O(logn) (this is because of max element in stack at any given point can be logn)

## 9. Quick Sort in array

Quick sort has avg-case as nlogn and worst case as n^2.

In-place, Not Stable,Not adaptive,Divide and conquer. It picks an element as pivot and partitions the given array around the picked pivot.

Perform quick sort algo to sort the data. for primitive it is preferred and for objects merge sort is preferred.

as merge sort takes extra o(n) memory it is not preferred for array.

but for linked list merge sort does not need extra space

**Steps**-

We will take one element as pivot(here the last one) and will try to put it in right position.

By right position we mean that all element to the left of it are small and right to it are greater than pivot.

So, basically we fixing pivot position one by one.

### Problem

Apply quick sort algorithm to sort array.

### Reference

ARRAY, LOCAL\_GIT

### Approach

**Partition –**

In partition algorithm we fix the pivot (here high index element) and if current element is less than pivot

We swap current element with low and increment low by 1.

Once loop terminates low element will be at index where high should be present so we swap it.

1. select high index element as pivot.

2. go from j=low to high-1.

3. check arr[j] < arr[high] . i.e. current element is smaller than pivot if yes.

4. swap j with low. and increment low by 1.

after loop terminates swap high with low. and return low which is our new pivot position.

e.g.

15, 17, 13, 6, 14

low high

j

step 1 -

15, 17, 13, 6, 14

low j high

15, 17, 13, 6, 14

low j high

13, 17, 15, 6, 14

low j high

13, 6, 15, 17, 14

low high

So,now swap high with low. and return low i.e. index 2.

So,that we will have two partition {13,6} {17,14} now and index 2 element is fixed

In this algorithm to save variable we will consider high as pivot.

### Solution

public void quickSort(int[] arr,int i, int j){

if (i < j) {

int p = partition(arr, i, j);

quickSort(arr, i, p-1);

quickSort(arr, p+1, j);

}

}

private int partition(int[] arr,int l,int h) {

int mid = (l+h)/2;

swap(arr,mid,h);

for(int i=l; i<h;i++){

if(arr[i]<arr[h]){

swap(arr,i,l);

l++;

}

}

swap(arr,l,h);

return l;

}

private void swap(int[] a, int i,int j){

int temp=a[i];

a[i]=a[j];

a[j]=temp;

}

### Time and space complexity

Avg Time - O(nlogn), worst case – O(n^2)

Space – O(1)

# 8. Selection problem

## 1. Find kth smallest element in array (Quick Select)

### Problem

Find kth smallest element in given array

### Reference

ARRAY, LEETCODE

### Approach

1. It is just little modification in quick sort algorithm.
2. Partition will remain same. And if index returned by partition is equal to k that means arr[k] is the kth smallest
3. If k is less than index received. It means we need to search between left, index-1.
4. Else search between index+1,right

### Solution

public int findkMinElement(int[] arr, int k) {

return kthSmallest(arr, 0, arr.length - 1, k - 1);

}

private int kthSmallest(int[] arr, int l, int r, int k) {

int p = partition(arr, l, r);

if (k == p) {

return arr[p];

} else if (k < p) {

return kthSmallest(arr, l, p - 1, k);

}

return kthSmallest(arr, p + 1, r, k);

}

public int partition(int[] arr, int start, int end) {

int initPivot = (start + end) / 2;

swap(arr, initPivot, end);

// after that end index will be our pivot. and we will put pivot to its correct

// position after loop terminates

for (int i = start; i < end; i++) {

if (arr[i] < arr[end]) {

swap(arr, i, start);

start++;

}

}

swap(arr, start, end);

return start;

}

private void swap(int[] arr, int i, int j) {

int temp = arr[i];

arr[i] = arr[j];

arr[j] = temp;

}

### Time and space complexity

Time - The worst case time complexity of this method is O(n2), but it works in O(n) on average.

Space - logn

# Bitwise operator

<https://www.youtube.com/watch?v=pv1C0_6k78A>

**1 Left shift <<**

a<<b will appends b number of zero to the end of binary equivalent of a. and return the decimal output.

It has similar effect as of multiplying the number ‘a’ with ‘b’ power of two.

For example –

a = 5 = 00000101

a << 1 = 00001010 = 10 (add 1 zero to last)

a << 2 = 00010100 = 20 (add 2 zero to last)

Basically a<<1 is multiplying a with 2^1 and a<<2 is multiplying a with 2^2

**2 Right shift >>**

a>>b will remove b number of digits from the end of binary equivalent of a. and return the decimal output.

It has similar effect as of dividing the number ‘a’ with ‘b’ power of two.

For example –

a = 10 = 00001010

a >> 1 = 00000101 = 5 (remove last digit. here it is 0)

a >> 2 = 00000010 = 2 (remove last two digits. here it is 10)

Basically a>>1 is dividing ‘a’ with 2^1 and a>>2 is dividing ‘a’ with 2^2.

**3 Bitwise OR (|)**

It returns bit by bit OR of input values, i.e, if either of the bits is 1, it gives 1, else it gives 0.

For example,

a = 5 = 0101 (In Binary)

b = 7 = 0111 (In Binary)

Bitwise OR Operation of 5 and 7

0101

| 0111

\_\_\_\_\_\_

0111 = 7 (In decimal)

**4 Bitwise AND &**

It returns bit by bit AND of input values, i.e., if both bits are 1, it gives 1, else it gives 0.

For example,

a = 5 = 0101 (In Binary)

b = 7 = 0111 (In Binary)

Bitwise AND Operation of 5 and 7

0101

& 0111

\_\_\_\_\_\_\_\_

0101 = 5 (In decimal)

**5 Bitwise XOR (^)**

It returns bit by bit XOR of input values, i.e, if corresponding bits are different, it gives 1, else it gives 0.

For example,

a = 5 = 0101 (In Binary)

b = 7 = 0111 (In Binary)

Bitwise XOR Operation of 5 and 7

0101

^ 0111

\_\_\_\_\_\_\_

0010 = 2 (In decimal)

**6 Bitwise Complement (~)**

It returns the one’s compliment representation of the input value, i.e, with all bits inversed, means it makes every 0 to 1, and every 1 to 0.

a = 5 = 0101 (In Binary)

Bitwise Compliment Operation of 5

~ 0101

\_\_\_\_\_\_\_\_

1010 = 10 (In decimal)

## 1. Convert Binary Number in a Linked List to Integer

### Problem

Given head which is a reference node to a singly-linked list. The value of each node in the linked list is either 0 or 1. The linked list holds the binary representation of a number.

Return the *decimal value* of the number in the linked list.

**Example 1:**



**Input:** head = [1,0,1]

**Output:** 5

**Explanation:** (101) in base 2 = (5) in base 10

### Reference

LEETCODE, GEEKSFORGEEKS

### Approach

1. start from head and keep on multiplying result with 2.
2. Result=result\*2 + head.val

For 100

Result = 0\*2+1=1

Result=1\*2+0=2

Result=2\*2+0=4

1. for multiplication by 2 we can use result<<1 also.

### Solution

public int getDecimalValue(ListNode head) {

int number = 0;

while(head!=null){

number=(number\*2)+head.val;

head=head.next;

}

return number;

}

### Time and space complexity

Time - O(n)

Space - O(1)

# 10. Binary Tree

1. A Tree with max 2 child’s are binary tree
2. Complete/full binary tree has all nodes with 2 child except leaf.
3. Binary Search Tree has property that left child is smaller than root and root is smaller than right.
4. Trees can be traversed in different ways. Following are the generally used ways for traversing trees.



*Example Tree*

1. Depth First Traversals:  
   (a) Inorder (Left, Root, Right) : It is just like printing node when visited second time

4 2 5 1 3  
(b) Preorder (Root, Left, Right): It is just like printing node when visited first time

1 2 4 5 3  
(c) Postorder (Left, Right, Root): It is just like printing node when visited third time

4 5 2 3 1

1. Breadth First or Level Order Traversal : printing node left to right level-wise from top to bottom.

1 2 3 4 5

1. Skewed binary tree is equivalent of single linked list.
2. To construct a unique binary tree we need in order traversal and any of these (pre-order/post order/level order)

**Therefore, following combination can uniquely identify a tree.**

Inorder and Preorder.

Inorder and Postorder.

Inorder and Level-order.

**And following do not.**

Postorder and Preorder.

Preorder and Level-order.

Postorder and Level-order.

1. Number of nodes in complete binary tree of height h is -> 2^(h+1) -1

18

/ \

15 30

/ \ / \ here h=2, so number of nodes => 2^3 - 1 => 7

40 50 100 40

1. Number of unordered binary tree possible with N Nodes-> 2ncn/(n+1). For 3 nodes 6c3/4

(6\*5\*4)/(4\*3\*2\*1) = 5

For n = 2, there are two trees

o o

/ \

o o

For n = 3, there are five trees

o o o o o

/ \ / \ / \

o o o o o o

/ \ \ /

o o o o

1. Number of ordered binary tree possible with N Nodes->

n!(2ncn/(n+1))

In above question n=3, total possible tree = 30 as every node can be root. So, 3! Possible combinations.

1. In Binary Tree every operation require entire tree traversal.
2. Degree of a node is the number of descendants of a node. If the degree is zero, it is called leaf node of a tree.

## Pre-Order Traversal Recursive

### Problem

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

### Reference

LEETCODE, GEEKSFORGEEKS, Ravindra Babu

### Approach

PreOrder (Root, Left, Right)

1

/ \

2 3

/ \

4 5

Output - 12453

i.e. whenever we visit node first time we print it.

Algorithm Preorder(tree)

1. Visit the root.

2. Traverse the left subtree, i.e., call Preorder(left-subtree)

3. Traverse the right subtree, i.e., call Preorder(right-subtree)

### Solution

**private** **void** preOrder(TreeNode<T> node) {

**if** (node != **null**) {

System.out.println(node.getData());

preOrder(node.getLeft());

preOrder(node.getRight());

}

}

### Time and space complexity

O(n)

O(n)

## Pre-Order Traversal Iterative

### Problem

Given a binary tree, return the pre-order traversal of its nodes' values.

### Reference

LEETCODE, GEEKSFORGEEKS

### Approach

1. It can be implemented using stack. We use our stack to hold objects just like in recursion.
2. Just add right child first and then left. As by this left object will be at the top of stack and popped first.
3. Pop all items one by one. Do following for every popped item

a) print it

b) push its right child

c) push its left child

Note that right child is pushed first so that left is processed first

### Solution

**public** **void** printPreOrderIterative(TreeNode<Integer> node) {

**if** (node == **null**) {

**return**;

}

Deque<TreeNode<Integer>> stack = **new** LinkedList<>();

stack.push(node);

**while** (!stack.isEmpty()) {

node = stack.pop();

System.***out***.print(node.getData() + " ");

**if** (node.getRight() != **null**) {

stack.push(node.getRight());

}

**if** (node.getLeft() != **null**) {

stack.push(node.getLeft());

}

}

System.***out***.println();

}

### Time and space complexity

O(n)

O(n)

## In-Order Traversal Recursive

### Problem

Given a binary tree, return the in-order traversal of its nodes' values.

### Reference

LEETCODE, GEEKSFORGEEKS, Ravindra Babu

### Approach

Inorder (Left, Root, Right)

1

/ \

2 3

/ \

4 5

Output - 42513

i.e. whenever we visit node second time we print it.

Algorithm Inorder(tree)

1. Traverse the left subtree, i.e., call Inorder(left-subtree)

2. Visit the root.

3. Traverse the right subtree, i.e., call Inorder(right-subtree)

### Solution

void printInorder(Node node) {

        if (node == null)

            return;

        printInorder(node.left);

        System.out.print(node.key + " ");

        printInorder(node.right); }

### Time and space complexity

O(n)

O(n)

## 4. In-Order Traversal Iterative

### Problem

Given a binary tree, return the in-order traversal of its nodes' values.

### Reference

LEETCODE, GEEKSFORGEEKS

### Approach

1. It can be implemented using stack. We use our stack to hold objects just like in recursion.

2. We will push all left nodes first and after that pop element which will be the last left node.

3. Print node and set current right. Now again repeat above step for current node

### Solution

**public** **void** printInOrderIterative(TreeNode<Integer> node) {

Deque<TreeNode<Integer>> st = **new** LinkedList<>();

**while** (!st.isEmpty() || node != **null**) {

**while** (node != **null**) {

st.push(node);

node = node.getLeft();

}

node = st.pop();

System.***out***.print(node.getData() + " ");

node = node.getRight();

}

System.***out***.println();

}

### Time and space complexity

O(n)

O(n)

## 5. Post-Order Traversal Recursive

### Problem

Given a binary tree, return the post order traversal of its nodes' values.

### Reference

LEETCODE, GEEKSFORGEEKS, Ravindra Babu

### Approach

postorder (Left, Root, Right)

1

/ \

2 3

/ \

4 5

Output - 45231

i.e. whenever we visit node third time we print it.

Algorithm Postorder(tree)

1. Traverse the left subtree, i.e., call Postorder(left-subtree)

2. Traverse the right subtree, i.e., call Postorder(right-subtree)

3. Visit the root.

### Solution

private void postorder(TreeNode root){

if(root!=null){

postorder(root.left);

postorder(root.right);

System.out.println(root.val);

}

}

### Time and space complexity

O(n)

O(n)

## Post-Order Traversal Iterative

### Problem

Given a binary tree, return the post order traversal of its nodes' values.

### Reference

LEETCODE, GEEKSFORGEEKS

### Approach

It is just like reversing the output of preorder traversal and hence we follow same algo as pre-order traversal iterative and to reverse the output we will take another stack.so, that when we pop from it data will be opposite

### Solution

**public** **void** printPostOrderIterative(TreeNode<Integer> node) {

**if** (node == **null**) {

**return**;

}

Deque<TreeNode<Integer>> stack = **new** LinkedList<>();

Deque<TreeNode<Integer>> result = **new** LinkedList<>();

stack.push(node);

**while** (!stack.isEmpty()) {

node = stack.pop();

result.push(node);

**if** (node.getLeft() != **null**) {

stack.push(node.getLeft());

}

**if** (node.getRight() != **null**) {

stack.push(node.getRight());

}

}

**while** (!result.isEmpty()) {

System.***out***.print(result.pop().getData() + " ");

}

System.***out***.println();

}

### Time and space complexity

O(n)

O(2n)

## Level-Order Traversal Iterative

### Problem

Given a binary tree, return the level order traversal of its nodes' values.

### Reference

LEETCODE, GEEKSFORGEEKS

### Approach

1. We will use queue data structure to store the node.
2. Get poll item from queue and For every node – first print data and then put left and right node in queue.

### Solution

**public** **void** printLevelOrder(TreeNode<Integer> root) {

**if** (root == **null**) {

**return**;

}

Queue<TreeNode<Integer>> queue = **new** LinkedList<>();

queue.add(root);

System.***out***.println("Level Order Traversal : ");

**while** (!queue.isEmpty()) {

TreeNode<Integer> node = queue.poll();

System.***out***.print(node.getData() + " ");

**if** (node.getLeft() != **null**) {

queue.add(node.getLeft());

}

**if** (node.getRight() != **null**) {

queue.add(node.getRight());

}

}

System.***out***.println();

}

### Time and space complexity

O(n)

O(n)

## Zig-Zag Order Traversal Iterative

### Problem

Given a binary tree, return the Zig-Zag traversal of its nodes' values. For the below binary tree the zigzag order traversal will be **1 3 2 7 6 5 4**



### Reference

LEETCODE, GEEKSFORGEEKS

### Approach

1. print data in level order traversal wise.
2. just print data left to right and right to left alternatively take two stacks.
3. one that is holding current level data and second using next level data.
4. just on alternate levels add left child first and then right child first.
5. in this way zig zag order will be maintained.
6. boolean is kept to alter the level once current level finished.
7. in case of current level is empty just swap it with with next level stack. As we are popping from current only.

### Solution

**public** **void** ZigZagTraversal(TreeNode<Integer> root) {

**if** (root == **null**) {

**return**;

}

Deque<TreeNode<Integer>> current = **new** LinkedList<>();

Deque<TreeNode<Integer>> next = **new** LinkedList<>();

current.push(root);

**boolean** leftToRight = **true**;

System.***out***.println("Zig Zag order traversal is : ");

**while** (!current.isEmpty()) {

TreeNode<Integer> node = current.pop();

System.***out***.print(node.getData() + " ");

**if** (leftToRight) {

**if** (node.getLeft() != **null**) {

next.push(node.getLeft());

}

**if** (node.getRight() != **null**) {

next.push(node.getRight());

}

} **else** {

**if** (node.getRight() != **null**) {

next.push(node.getRight());

}

**if** (node.getLeft() != **null**) {

next.push(node.getLeft());

}

}

**if** (current.isEmpty()) {

leftToRight = !leftToRight;

Deque<TreeNode<Integer>> temp = current;

current = next;

next = temp;

}

}

System.***out***.println();

}

### Time and space complexity

O(n)

O(n)

## 9. Binary Tree Tilt

### Problem

Given a binary tree, return the tilt of the **whole tree**.

The tilt of a **tree node** is defined as the **absolute difference** between the sum of all left subtree node values and the sum of all right subtree node values. Null node has tilt 0.

The tilt of the **whole tree** is defined as the sum of all nodes' tilt.

**Example:**

Input :

4

/ \

2 9

/ \ \

3 5 7

Output : 15

Explanation:

Tilt of node 3 : 0

Tilt of node 5 : 0

Tilt of node 7 : 0

Tilt of node 2 : |3-5| = 2

Tilt of node 9 : |0-7| = 7

Tilt of node 4 : |(3+5+2)-(9+7)| = 6

Tilt of binary tree : 0 + 0 + 0 + 2 + 7 + 6 = 15

### Reference

LEETCODE, GEEKSFORGEEKS

### Approach

1. Will use recursive solution to get the tilt value of full tree.
2. Will take global variable sum to hold the total sum.
3. Call left tree and then right.
4. we will store the total tilt value inside sum variable and return value of current node
5. for e.g. will return 0+0+3 as left and 0+0+5 as right for node 2
6. So, will update sum= 0+|3-5| => 2 for node 2.
7. We will do for all the nodes like this.

### Solution

class Model{

int sum;

}

public int findTilt(TreeNode root) {

Model m = new Model();

findTilt(root,m);

return m.sum;

}

private int findTilt(TreeNode root,Model m){

if(root==null){

return 0;

}

int l = findTilt(root.left,m);

int r = findTilt(root.right,m);

m.sum = Math.abs(l-r)+m.sum;

return l+r+root.val;

}

### Time and space complexity

O(n)

O(n)

# 11. Binary Search Tree

Binary Search Tree is a node-based binary tree data structure which has the following properties: The left subtree of a node contains only nodes with keys lesser than the node's key. The right subtree of a node contains only nodes with keys greater than the node's key.

200px-Binary_search_tree.svg

1. Searching is faster as compared to binary tree as we ignore half tree every time
2. In case of balanced BST time to find node – logn
3. In worst case if data added in sorted order in tree. It will became skew tree (like single linked list) & will take o(n)
4. AVL tree, Red Black Tree are balanced binary search tree which ensure every operation takes logn time
5. In order traversal of Binary Search Tree is sorted data.
6. If we have pre-order or postorder only we can construct a unique bst. This is because we can get in-order by sorting post order or pre order.
7. Whenever we need to traverse tree bottom up we can try in-order approach.

## 1. Search in Binary Search Tree Recursive

### Problem

Given the root node of a binary search tree (BST) and a value. You need to find the node in the BST that the node's value equals the given value. Return the subtree rooted with that node. If such node doesn't exist, you should return NULL.

For example,

Given the tree:

4

/ \

2 7

/ \

1 3

And the value to search: 2

You should return this subtree:

2

/ \

1 3

In the example above, if we want to search the value 5, since there is no node with value 5, we should return NULL.

### Reference

LEETCODE, BINARY SEARCH TREE, BST

### Approach

1. Call recursively till we match node.val with val
2. If val<root.val call searchBST(root.left,val) else searchBST(root.right,val)

### Solution

public TreeNode searchBST(TreeNode root, int val) {

if(root==null||root.val==val){

return root;

}

if(val<root.val){

return searchBST(root.left,val);

}

return searchBST(root.right,val);

}

### Time and space complexity

O(logn)- avg case and o(n) worst case

O(1)

# 12. Dynamic Programming

## 1. Maximum sum in Contiguous Sub-Array

### Problem

Given an integer array nums, find the contiguous subarray (containing at least one number) which has the largest sum and return its sum.

Example:

Input: [-2,1,-3,4,-1,2,1,-5,4],

Output: 6

Explanation: [4,-1,2,1] has the largest sum = 6.

### Reference

LEETCODE, UDEMY, DP

### Approach

\*Take global\_max which hold the max overall

\* And curr\_max will hold the max till curr iteration.

\* We will update curr\_max by this - store max of (current element, curr\_max+current element)

\* By this we make sure that either current is taken or previous one is included in contiguous space.

### Solution

public int maxSubArray(int[] nums) {

int curr\_max = nums[0];

int global\_max = nums[0];

for (int i = 1; i < nums.length; i++) {

curr\_max = MathUtil.max(nums[i], nums[i] + curr\_max);

if (curr\_max > global\_max) {

global\_max = curr\_max;

}

}

return curr\_max;

}

### Time and space complexity

O(n)

O(n)

# 13. Design data structure

## 1. Design LRU cache with put and get in o(1) time

### Problem

Design and implement a data structure for [Least Recently Used (LRU) cache](https://en.wikipedia.org/wiki/Cache_replacement_policies#LRU). It should support the following operations: get and put.

get(key) - Get the value (will always be positive) of the key if the key exists in the cache, otherwise return -1.  
put(key, value) - Set or insert the value if the key is not already present. When the cache reached its capacity, it should invalidate the least recently used item before inserting a new item.

The cache is initialized with a **positive** capacity.

Example –

LRUCache cache = new LRUCache( 2 /\* capacity \*/ );

cache.put(1, 1);

cache.put(2, 2);

cache.get(1); // returns 1

cache.put(3, 3); // evicts key 2

cache.get(2); // returns -1 (not found)

cache.put(4, 4); // evicts key 1

cache.get(1); // returns -1 (not found)

cache.get(3); // returns 3

cache.get(4); // returns 4

### Reference

LEETCODE, GIT

### Approach

1. since we want to retrieve data in o(1) we will use hashmap. And we will use double-linked-list to store data.

2. Head and last are used to hold linked list.

3. we will remove from last and insert at head.

4. when we get item. In that case we remove it and insert node at head.

5. when we put if capacity is full. We remove from last and insert node at head.

6. to simplify exceptional cases like only last or only head is present or delete last or head element. We keep head and last as dummy value with 0 data.

7. so, we are always sure that head and last always exist and we use map.size to know current capacity.

### Solution

**public** **class** LRUCacheSimplified {

**class** Node {

**int** key;

**int** value;

Node prev;

Node next;

Node(**int** k, **int** v) {

key = k;

value = v;

}

}

**private** Map<Integer, Node> map = **new** HashMap<>();

**private** Node head;

**private** Node last;

**private** **int** capacity;

**public** LRUCacheSimplified(**final** **int** capacity) {

**this**.capacity = capacity;

head = **new** Node(0, 0);

last = **new** Node(0, 0);

head.next = last;

last.prev = head;

}

**public** **int** get(**int** key) {

Node node = map.get(key);

**if** (node == **null**) {

**return** -1;

}

remove(node);

insert(node);

**return** node.value;

}

**private** **void** insert(Node node) {

map.put(node.key, node);

node.next = head.next;

head.next.prev = node;

node.prev = head;

head.next = node;

}

**public** **void** put(**int** key, **int** value) {

**if** (map.containsKey(key)) {

remove(map.get(key));

}

**if** (map.size() == capacity) {

remove(last.prev);

}

insert(**new** Node(key, value));

}

**private** **void** remove(Node node) {

map.remove(node.key);

node.prev.next = node.next;

node.next.prev = node.prev;

}

}

### Time and space complexity

O(1) – for put and get

O(n), n is no. of the key stored in the hashmap and the doubly linked list