

VISVESVARAYA TECHNOLOGICAL UNIVERSITY

“GnanaSangama”, Belgaum -590014, Karnataka.



LAB REPORT On

DATA STRUCTURES (23CS3PCDST)

Submitted by

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**in partial fulfillment for the award of the degree of
BACHELOR OF ENGINEERING
in
COMPUTER SCIENCE AND ENGINEERING**



**B.M.S. COLLEGE OF ENGINEERING
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Department of Computer Science and Engineering**



This is to certify that the Lab work entitled “**DATA STRUCTURES**” carried out by Pranav Y (**1BM22CS204**), who is a bonafide student of **B. M. S. College of Engineering**. It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum during the year 2023-24. The Lab report has been approved as it satisfies the academic requirements in respect of Data structures Lab - (**23CS3PCDST**) work prescribed for the said degree.

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Course outcomes:

CO1	Apply the concept of linear and nonlinear data structures.
CO2	Analyze data structure operations for a given problem
CO3	Design and develop solutions using the operations of linear and nonlinear data structure for a given specification.
CO4	Conduct practical experiments for demonstrating the operations of different data structures.

Lab program 1:

Write a program to simulate the working of stack using an array with the following:

- a) Push
- b) Pop
- c) Display

The program should print appropriate messages for stack overflow, stack underflow.

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define size 10
int pos = -1;
int stack[size];

void push(int a);
int pop();
void display();

int main(){
    printf("1. Push\n2. Pop\n3. Display stack\n4. Exit\nEnter\nchoice: ");
    int choice;
    int a;
    scanf("%d", &choice);
    while(choice != 4){
        switch(choice){
            case 1:
                printf("Enter integer to be pushed: ");
                scanf("%d", &a);
                push(a);
                break;
            case 2:
                a = pop();
                printf("Integer poppped = %d\n", a);
                break;
            case 3:
                display();
                break;
            default:
                printf("Invalid input");
                break;
        }
    }
}
```

```

        }
        printf("Enter choice: ");
        scanf("%d", &choice);
    }

}

void push(int a){
    if (pos == 9){
        printf("Stack Overflow condition");
        return;
    }
    stack[++pos] = a;
}

int pop(){
    if (pos == -1){
        printf("Stack Underflow condition");
        return (int) NULL;
    }
    return stack[pos--];
}

void display(){
    for(int i = 0; i < size; i++){
        printf("%d ", stack[i]);
    }
    printf("\n");
}

```

Output:

```
1. Push
2. Pop
3. Display stack
4. Exit
Enter choice: 1
Enter integer to be pushed: 3
Enter choice: 1
Enter integer to be pushed: 4
Enter choice: 2
Integer poppped = 4
Enter choice: 1
Enter integer to be pushed: 5
Enter choice: 3
3 5 0 0 0 0 0 0 0
Enter choice: 4
```

Lab program 2:

WAP to convert a given valid parenthesized infix arithmetic expression to postfix expression. The expression consists of single character operands and the binary operators + (plus), - (minus), * (multiply) and / (divide)

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <stdbool.h>

#define size 20

void push(char a);
char pop();
void display();
char* postfix(char* exp);
char* prefix(char* exp);
bool character(char c);
bool lower_precedence(char op1, char op2);
bool isEmpty();

int pos = -1;
char stack[size];
int n;
```

```

int main(){

    printf("Enter size of expression in terms of characters: ");
    scanf("%d", &n);
    fflush(stdin);
    char* expr = (char*) malloc(size*sizeof(char));
    printf("Enter infix expression: ");
    scanf("%[^\n]s", expr);
    char* postfixexp = postfix(expr);
    printf("Postfix expression: %s\n", postfixexp);
    char* prefixexp = prefix(expr);
    printf("Prefix expression: %s", prefixexp);

    return 0;
}

bool isEmpty(){
    return pos == -1;
}

void push(char a){
    if (pos == size-1){
        printf("Stack Overflow condition");
        return;
    }
    stack[++pos] = a;
}

char pop(){
    if (pos == -1){
        printf("Stack Underflow condition");
        return (char) NULL;
    }

    char return_value = stack[pos];
    stack[pos] = (char) NULL;
    pos--;
    return return_value;
}

void display(){
    printf("Stack: ");

```

```

    for(int i = 0; i < size; i++){
        printf("%c ", stack[i]);
    }
    printf("\n");
}

bool character(char c){
    return (c >= 'a' && c <= 'z') || (c >= 'A' && c <= 'Z') || (c
    >= '0' && c <= '9');
}

bool lower_precedence(char op1, char op2){
    if (op1 == op2 && op2 == '^') return false;
    char op_order[] = {'^', '/', '*', '+', '-'};
    int o1, o2;
    for(int i = 0; i < 5; i++){
        if (op_order[i] == op1) o1 = i;
        if (op_order[i] == op2) o2 = i;
    }

    return o1 <= o2;
}

char* postfix(char* exp){
    char* return_exp = (char*) malloc((size+3)*sizeof(char));
    int current = 0;
    for(int i = 0; i < n; i++){

        if (character(exp[i])){
            return_exp[current++] = exp[i];
        }
        else if(exp[i] == '+' || exp[i] == '-' || exp[i] == '*' ||
exp[i] == '/' || exp[i] == '^'){
            if (isEmpty()) push(exp[i]);

            else if(lower_precedence(stack[pos], exp[i])){
                while(lower_precedence(stack[pos], exp[i]) &&
!isEmpty()){
                    if (stack[pos] != '(') return_exp[current++] =
pop();
                    else{

```



```

        pos--;
        break;
    }
    }
    push(exp[i]);
}
else push(exp[i]);
}
else if(exp[i] == '('){
    push('(');
}
else if(exp[i] == ')'){
    while(stack[pos] != '(' && !isEmpty()){
        return_exp[current++] = pop();
    }
}
}

}

while(!isEmpty()){
    if (stack[pos] != '(') return_exp[current++] = pop();
    else pos--;
}

return return_exp;

}

char* prefix(char* exp){
    char* buffer = malloc(size*sizeof(char));
    for(int i = n-1; i >= 0; i--){
        buffer[n-i-1] = exp[i];
        if (buffer[n-i-1] == '(') buffer[n-i-1] = ')';
        else if (buffer[n-i-1] == ')') buffer[n-i-1] = '(';
    }

    printf("Reversed String: %s\n", buffer);
    char* return_exp = malloc(size*sizeof(char));
    int current = 0;
    for(int i = 0; i < n; i++){

```

```

        if (character(buffer[i])){
            return_exp[current++] = buffer[i];
        }
        else if(buffer[i] == '+' || buffer[i] == '-' || buffer[i]
== '*' || buffer[i] == '/' || buffer[i] == '^'){
            if (isEmpty()) push(buffer[i]);

            else if(lower_precedence(stack[pos], buffer[i])){
                while(lower_precedence(stack[pos], buffer[i]) &&
!isEmpty()){
                    if (stack[pos] != '(') return_exp[current++] =
pop();

                    else{
                        pos--;
                        break;
                    }
                }
                push(buffer[i]);
            }
            else push(buffer[i]);
        }
        else if(buffer[i] == '('){
            push('(');
        }
        else if(buffer[i] == ')'){
            while(stack[pos] != '(' && !isEmpty()){
                return_exp[current++] = pop();
            }
        }
    }

}

while(!isEmpty()){
    if (stack[pos] != '(') return_exp[current++] = pop();
    else pos--;
}

char* final = (char*) malloc(size*sizeof(char));
for(int i = 0; i < strlen(return_exp); i++)

```

```
        final[i] = return_exp[strlen(return_exp)-i-1];  
    }  
    return final;  
}
```

Output:

```
Enter size of expression in terms of characters: 9
Enter infix expression: a*b+c*d-e
Postfix expression: ab*cd*+e-
```

Lab 3:

3a)

WAP to simulate the working of a queue of integers using an array. Provide the following operations: Insert, Delete, Display. The program should print appropriate messages for queue empty and queue overflow conditions.

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>
#include <string.h>

#define size 5

void push(int a);
int pop();
void display();

int fpos = -1, rpos = -1;
int queue[size];

int main(){
    int choice;
    printf("1. Enqueue\n2. Dequeue\n3. Display\n4. Exit\nEnter\nchoice: ");
    scanf("%d", &choice);
    int a;
    while(choice != 4){
        switch(choice){
            case 1:
                printf("Enter integer to be pushed: ");
                scanf("%d", &a);
                push(a);
```

```

        break;
    case 2:
        a = pop();
        printf("Popped integer = %d\n", a);
        break;
    case 3:
        display();
        break;
    default:
        printf("Idk");
        break;
    }
    printf("Enter choice: ");
    scanf("%d", &choice);
}

}

void push(int a){
    if (fpos == -1 && rpos == -1){
        queue[++rpos] = a;
        fpos++;
        return;
    }
    else if (rpos == size-1){
        printf("Queue overflow condition\n");
        return;
    }
    else{
        queue[++rpos] = a; return;
    }
}

int pop(){
    if (fpos == -1){
        printf("Queue Underflow condition\n");
    }
    int n = queue[fpos];
    queue[fpos] = (int) NULL;
    fpos++;
    return n;
}

```

```

void display(){
    printf("Queue: ");
    for(int i = 0; i < size; i++)
        printf("%d ", queue[i]);
    printf("\n");
}

```

Output:

```

1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter choice: 1
Enter integer to be pushed: 2
Enter choice: 1
Enter integer to be pushed: 3
Enter choice: 1
Enter integer to be pushed: 4
Enter choice: 1
Enter integer to be pushed: 5
Enter choice: 1
Enter integer to be pushed: 6
Enter choice: 3
Queue: 2 3 4 5 6
Enter choice: 2
Popped integer = 2
Enter choice: 2
Popped integer = 3
Enter choice: 3
Queue: 0 0 4 5 6
Enter choice: 1
Enter integer to be pushed: 7
Queue overflow condition
Enter choice: 4

Process returned 0 (0x0)   execution time : 28.952 s

```

3b) WAP to simulate the working of a circular queue of integers using an array. Provide the following operations: Insert, Delete & Display. The program should print appropriate messages for queue empty and queue overflow conditions

Code:

```

#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>

```

```

#include <string.h>

#define size 5

void push(int a);
int pop();
void display();

int fpos = -1, rpos = -1;
int queue[size];

int main(){
    int choice;
    printf("1. Enqueue\n2. Dequeue\n3. Display\n4. Exit\nEnter
choice: ");
    scanf("%d", &choice);
    int a;
    while(choice != 4){
        switch(choice){
            case 1:
                printf("Enter integer to be pushed: ");
                scanf("%d", &a);
                push(a);
                // printf("fpos = %d; rpos = %d\n", fpos%size,
rpos%size);
                break;
            case 2:
                a = pop();
                printf("Popped integer = %d\n", a);
                // printf("fpos = %d; rpos = %d\n", fpos%size,
rpos%size);
                break;
            case 3:
                display();
                break;
            default:
                printf("Idk");
                break;
        }
        printf("Enter choice: ");
        scanf("%d", &choice);
    }
}

```

```

}

void push(int a){
    if (fpos == -1 && rpos == -1){
        queue[++rpos] = a;
        fpos++;
        return;
    }
    else if ((rpos+1)%size == (fpos%size)){
        printf("Queue overflow condition\n");
        return;
    }
    else{
        rpos++;
        queue[(rpos%size)] = a;
        return;
    }
}

int pop(){
    if (fpos == -1){
        printf("Queue Underflow condition\n");
    }
    int n = queue[fpos%size];
    queue[fpos%size] = (int) NULL;
    fpos++;
    return n;
}

void display(){
    printf("Queue: ");
    for(int i = 0; i < size; i++)
        printf("%d ", queue[i]);
    printf("\n");
}

```


Output:

```
1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter choice: 1
Enter integer to be pushed: 2
Enter choice: 1
Enter integer to be pushed: 3
Enter choice: 1
Enter integer to be pushed: 4
Enter choice: 1
Enter integer to be pushed: 5
Enter choice:
1
Enter integer to be pushed: 6
Enter choice: 3
Queue: 2 3 4 5 6
Enter choice: 2
Popped integer = 2
Enter choice: 3
Queue: 0 3 4 5 6
Enter choice: 1
Enter integer to be pushed: 1
Enter choice: 3
Queue: 1 3 4 5 6
Enter choice: 2
Popped integer = 3
Enter choice: 3
Queue: 1 0 4 5 6
Enter choice: 4

Process returned 0 (0x0)   execution time : 32.409 s
```

Lab 4:

WAP to Implement Singly Linked List with following operations

- a) Create a linked list.
- b) Insertion of a node at first position, at any position and at end of list.

Display the contents of the linked list.

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>

typedef struct Node{
```

```

    int data;
    struct Node *next;
} node;

node* head = NULL;
int count = 0;

void insert(int data, int position);
void display();

int main(){
    int data, choice, pos;
    printf("1. Insert\n2. Delete\n3. Exit\nChoice: ");
    scanf("%d", &choice);
    while(choice != 2){
        if (choice == 1){
            printf("Enter data and position: ");
            scanf("%d%d", &data, &pos);
            insert(data, pos);
            printf("Count: %d\n", count);
        }
        display();
        printf("Enter choice: ");
        scanf("%d", &choice);
    }

    return 0;
}

void insert(int data, int position){
    if (position == 0){
        node* new_node = (node*)malloc(sizeof(node));
        new_node->data = data;
        new_node->next = NULL;
        head = new_node;
        count++;
        return;
    } else if (position == count){
        node* new_node = malloc(sizeof(node));
        new_node->data = data;

```

```

    new_node->next = NULL;
    node* temp = head;
    while(temp->next != NULL)
        temp = temp->next;
    temp->next = new_node;
    count++;
    return;

} else if (position > count || position < 0){
    printf("Unable to insert at given position\n");
    return;
} else {
    node* temp = head;
    for(int i = 0; i < position-1; i++)
        temp = temp->next;
    node* new_node = malloc(sizeof(node));
    new_node->data = data;
    new_node->next = temp->next;
    temp->next = new_node;
    count++;
    return;
}
}

```

Output:

```

1. Insert
2. Delete
3. Exit
Choice: 1
Enter data and position: 1 0
Count: 1
Linked List: 1
Enter choice: 1
Enter data and position: 2 1
Count: 2
Linked List: 1 2
Enter choice: 1
Enter data and position: 3 2
Count: 3
Linked List: 1 2 3
Enter choice: 1
Enter data and position: 4 1
Count: 4
Linked List: 1 4 2 3
Enter choice: 1
Enter data and position: 5 2
Count: 5
Linked List: 1 4 5 2 3
Enter choice: 3

Process returned 0 (0x0)   execution time : 47.266 s
Press any key to continue.

```

Program - Leetcode platform:

Design a stack that supports push, pop, top, and retrieving the minimum element in constant time.

Implement the MinStack class:

MinStack() initializes the stack object.

void push(int val) pushes the element val onto the stack.

void pop() removes the element on the top of the stack.

int top() gets the top element of the stack.

int getMin() retrieves the minimum element in the stack.

You must implement a solution with O(1) time complexity for each function.

Code:

```
typedef struct {
```

```

    int stack[300000];
    int min;
    int top;
} MinStack;

MinStack* minStackCreate() {
    MinStack* obj = malloc(sizeof(MinStack));
    obj->top = -1;
    obj->min = INT_MAX;
    return obj;
}

void minStackPush(MinStack* obj, int val) {
    if (val <= obj->min){
        obj->stack[++(obj->top)] = obj->min;
        obj->min = val;
    }
    obj->stack[++(obj->top)] = val;
    return;
}

void minStackPop(MinStack* obj) {
    if (obj->stack[obj->top] == obj->min){
        obj->stack[obj->top] = NULL;
        obj->top -= 1;
        obj->min = obj->stack[(obj->top)];
    }
    obj->stack[obj->top] = NULL;
    obj->top -= 1;
}

int minStackTop(MinStack* obj) {
    return obj->stack[obj->top];
}

int minStackGetMin(MinStack* obj) {
    return obj->min;
}

void minStackFree(MinStack* obj) {
    free(obj);
}

```

}

Output:

Accepted	C	34 ms	18.4 MB
Accepted	C	27 ms	18.5 MB
Accepted	C++	19 ms	16.7 MB

```
1 typedef struct {
2     int stack[300000];
3     int min;
4     int top;
5 } MinStack;
6
7
8 MinStack* minStackCreate() {
9     MinStack* obj = malloc(sizeof(MinStack));
10    obj->top = -1;
11    obj->min = INT_MAX;
12    return obj;
13 }
14
15 void minStackPush(MinStack* obj, int val) {
16     if (val <= obj->min){
17         obj->stack[++(obj->top)] = obj->min;
18         obj->min = val;
19     }
20     obj->stack[++(obj->top)] = val;
21     return;
22 }
23
24 void minStackPop(MinStack* obj) {
25     if (obj->stack[obj->top] == obj->min){
26         obj->stack[obj->top] = NULL;
27         obj->top -= 1;
28         obj->min = obj->stack[(obj->top)];
29     }
30     obj->stack[obj->top] = NULL;
```

Lab 5:

WAP to Implement Singly Linked List with following operations

- Create a linked list.
- Deletion of first element, specified element and last element in the list.
- Display the contents of the linked list.

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>
```

```
typedef struct Node{
```

```

    int data;
    struct Node *next;
} node;

node* head = NULL;
int count = 0;

void insert(int data, int position);
void delete(int position);
void display();

int main(){
    int data, choice, pos;
    printf("1. Insert\n2. Delete\n3. Exit\nChoice: ");
    scanf("%d", &choice);
    while(choice != 3){
        if (choice == 1){
            printf("Enter data and position: ");
            scanf("%d%d", &data, &pos);
            insert(data, pos);
            printf("Count: %d\n", count);
        } else if (choice == 2){
            printf("Enter position: ");
            scanf("%d", &pos);
            delete(pos);
            printf("Count: %d\n", count);
        }
        display();
        printf("Enter choice: ");
        scanf("%d", &choice);
    }

    return 0;
}

void insert(int data, int position){
    if (position == 0){
        node* new_node = (node*)malloc(sizeof(node));
        new_node->data = data;
        new_node->next = head;
        head = new_node;
    }
}

```

```

        count++;
        return;

    } else if (position == count){
        node* new_node = malloc(sizeof(node));
        new_node->data = data;
        new_node->next = NULL;
        node* temp = head;
        while(temp->next != NULL)
            temp = temp->next;
        temp->next = new_node;
        count++;
        return;

    } else if (position > count || position < 0){
        printf("Unable to insert at given position\n");
        return;
    } else {
        node* temp = head;
        for(int i = 0; i < position-1; i++)
            temp = temp->next;
        node* new_node = malloc(sizeof(node));
        new_node->data = data;
        new_node->next = temp->next;
        temp->next = new_node;
        count++;
        return;
    }
}

void delete(int position){
    if (position == 0){
        node* temp = head;
        head = head->next;
        free(temp);
        count--;
        return;
    } else if (position == count-1){
        node* temp = head;
        for(int i = 1; i < count-1; i++)
            temp = temp->next;
        node* temp1 = temp->next;

```



```

        temp->next = NULL;
        free(temp1);
        count--;
        return;
    } else if (position > count || position < 0){
        printf("Unable to delete at given position\n");
        return;
    } else {
        node* temp = head;
        for(int i = 0; i < position-1; i++)
            temp = temp->next;
        node* temp1 = temp->next;
        temp->next = temp1->next;
        free(temp1);
        count--;
        return;
    }
}

void display(){
    node* temp = head;
    printf("Linked List: ");
    while (temp->next != NULL){
        printf("%d ", temp->data);
        temp = temp->next;
    }
    printf("%d ", temp->data);
    printf("\n");
}

```

Output:

```
3. Exit
Choice: 1
Enter data and position: 1 0
Count: 1
Linked List: 1
Enter choice: 1
Enter data and position: 2 1
Count: 2
Linked List: 1 2
Enter choice: 1
Enter data and position: 3 2
Count: 3
Linked List: 1 2 3
Enter choice: 1
Enter data and position: 4 3
Count: 4
Linked List: 1 2 3 4
Enter choice: 2
Enter position: 0
Count: 3
Linked List: 2 3 4
Enter choice: 2
Enter position: 1
Count: 2
Linked List: 2 4
Enter choice: 2
Enter position: 1
Count: 1
Linked List: 2
```

Program - Leetcode platform

Given the head of a singly linked list, reverse the list, and return *the reversed list*.

Code:

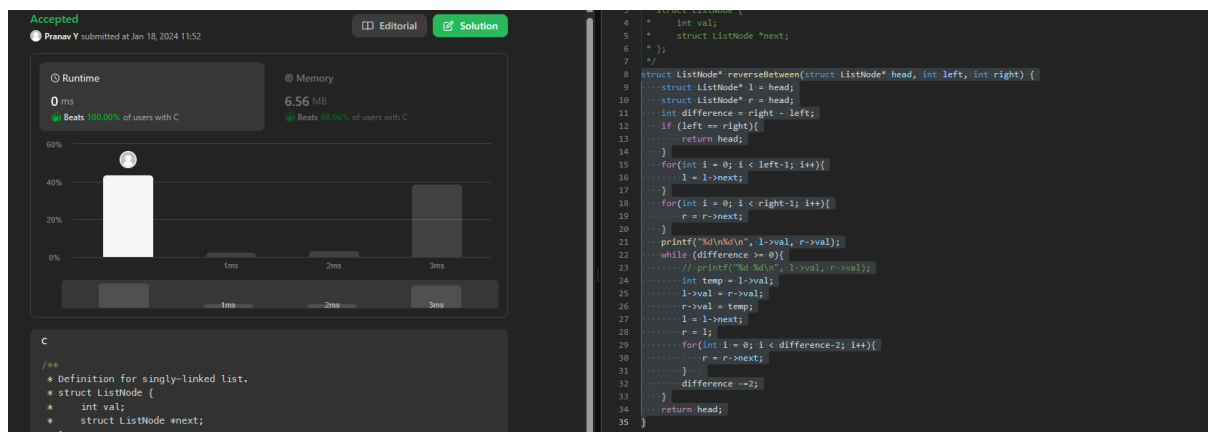
```
struct ListNode* reverseBetween(struct ListNode* head, int left,
int right) {
    struct ListNode* l = head;
    struct ListNode* r = head;
    int difference = right - left;
    if (left == right){
        return head;
    }
    for(int i = 0; i < left-1; i++){
```

```

        l = l->next;
    }
    for(int i = 0; i < right-1; i++){
        r = r->next;
    }
    printf("%d\n%d\n", l->val, r->val);
    while (difference >= 0){
        // printf("%d %d\n", l->val, r->val);
        int temp = l->val;
        l->val = r->val;
        r->val = temp;
        l = l->next;
        r = l;
        for(int i = 0; i < difference-2; i++){
            r = r->next;
        }
        difference -=2;
    }
    return head;
}

```

Output:



Lab 6

a) WAP to Implement Single Link List with following operations:

- Sort the linked list
- Reverse the linked list
- Concatenation of two linked lists.

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>

typedef struct Node{
    int data;
    struct Node *next;
} node;

node *head = NULL;
node *head1 = NULL;
int count = 0;

void insert(int data, int position);
void delete(int position);
void display();
void sort();
void reverse();
void concat(node** head1, node** head2);

int main(){
    insert(2, 0);
    insert(1, 1);
    insert(4, 2);
    insert(3, 3);
    insert(5, 4);
    printf("Original Linked List: \n");
    display();
    sort();
    printf("Sorted Linked List: \n");
    display();
    reverse();
```

```

printf("Reversed Linked List: \n");
display();
head1 = head;
head = NULL;
insert(3, 0);
insert(4, 1);
insert(1, 2);
display();
concat(&head1, &head);
head = head1;
printf("Concatenating with the above linked list gives: \n");
display();

return 0;
}

void insert(int data, int position){
    if (position == 0){
        node* new_node = (node*)malloc(sizeof(node));
        new_node->data = data;
        new_node->next = head;
        head = new_node;
        count++;
        return;

    } else if (position == count){
        node* new_node = malloc(sizeof(node));
        new_node->data = data;
        new_node->next = NULL;
        node* temp = head;
        while(temp->next != NULL)
            temp = temp->next;
        temp->next = new_node;
        count++;
        return;

    } else if (position > count || position < 0){
        printf("Unable to insert at given position\n");
        return;
    } else {
        node* temp = head;
        for(int i = 0; i < position-1; i++)

```

```

        temp = temp->next;
        node* new_node = malloc(sizeof(node));
        new_node->data = data;
        new_node->next = temp->next;
        temp->next = new_node;
        count++;
        return;
    }
}

void delete(int position){
    if (position == 0){
        node* temp = head;
        head = head->next;
        free(temp);
        count--;
        return;
    } else if (position == count-1){
        node* temp = head;
        for(int i = 1; i < count-1; i++)
            temp = temp->next;
        node* temp1 = temp->next;
        temp->next = NULL;
        free(temp1);
        count--;
        return;
    } else if (position > count || position < 0){
        printf("Unable to delete at given position\n");
        return;
    } else {
        node* temp = head;
        for(int i = 0; i < position-1; i++)
            temp = temp->next;
        node* temp1 = temp->next;
        temp->next = temp1->next;
        free(temp1);
        count--;
        return;
    }
}

void sort(){

```

```

int i, j, min_index;
node *i_node=head, *j_node=head, *min_node=NULL;
for(int i = 0; i < count-1; i++, i_node=i_node->next){
    // printf("Got here\n");
    min_index = i;
    min_node = i_node;
    j_node = i_node->next;
    for(int j = i+1; j < count; j++, j_node=j_node->next){
        // printf("Got here too\n");
        if (j_node->data < i_node->data){
            min_index = j;
            min_node = j_node;
        }
    }
    // printf("%d\n", min_index);
    if (min_index != i){
        // printf("Found a min element\n");
        int temp = i_node->data;
        i_node->data = min_node->data;
        min_node->data = temp;
        // display();
    }
}
}

void reverse(){
    node *prev = NULL, *next=NULL;
    while(head != NULL){
        next = head->next;
        head->next = prev;
        prev = head;
        head = next;
    }
    head = prev;
}

void concat(node **head1, node **head2){
    node *temp1 = *head1;
    while (temp1->next != NULL){
        temp1 = temp1->next;
    }
    // printf("Got here atleast?\n");

```

```

    temp1->next = *head2;
    // printf("Got here?\n");
}

void display(){
    node* temp = head;
    printf("Linked List: ");
    while (temp->next != NULL){
        printf("%d ", temp->data);
        temp = temp->next;
    }
    printf("%d ", temp->data);
    printf("\n");
}

```

Output:

```

Original Linked List:
Linked List: 2 1 4 3 5
Sorted Linked List:
Linked List: 1 2 3 4 5
Reversed Linked List:
Linked List: 5 4 3 2 1
Linked List: 3 4 1
Concatenating with the above linked list gives:
Linked List: 5 4 3 2 1 3 4 1

Process returned 0 (0x0)   execution time : 0.016 s
Press any key to continue.

```

6b) WAP to Implement Single Link List to simulate Stack & Queue Operations.

i) Stack

```

#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>

typedef struct Node{
    int data;
    struct Node *next;
} node;

node* head = NULL;
int count = 0;

```



```

void insert(int data);
int delete();
void display();

int main(){
    int data, choice, pos;
    printf("1. Insert\n2. Delete\n3. Exit\nChoice: ");
    scanf("%d", &choice);
    while(choice != 3){
        if (choice == 1){
            printf("Enter data: ");
            scanf("%d", &data);
            insert(data);
            printf("Count: %d\n", count);
        } else if (choice == 2){
            printf("Integer popped = %d\n", delete());
            printf("Count: %d\n", count);
        }
        display();
        printf("Enter choice: ");
        scanf("%d", &choice);
    }

    return 0;
}

void insert(int data){
    node* new_node = (node*)malloc(sizeof(node));
    new_node->data = data;
    new_node->next = head;
    head = new_node;
    count++;
    return;
}

int delete(){
    node* temp = head;
    head = head->next;
    int t = temp->data;

```

```

        free(temp);
        count--;
        return t;
    }

void display(){
    node* temp = head;
    printf("Stack: ");
    while (temp->next != NULL){
        printf("%d ", temp->data);
        temp = temp->next;
    }
    printf("%d ", temp->data);
    printf("\n");
}

```

Output:

```

1. Insert
2. Delete
3. Exit
Choice: 1
Enter data: 3
Count: 1
Linked List: 3
Enter choice: 1
Enter data: 2
Count: 2
Linked List: 2 3
Enter choice: 1
Enter data: 5
Count: 3
Linked List: 5 2 3
Enter choice: 2
Integer popped = 5
Count: 2
Linked List: 2 3
Enter choice: 2
Integer popped = 2
Count: 1
Linked List: 3
Enter choice: 3

Process returned 0 (0x0)   execution time : 14.281 s
Press any key to continue.

```

ii)Queue

```
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>

typedef struct Node{
    int data;
    struct Node *next;
} node;

node* head = NULL;
int count = 0;

void insert(int data);
int delete();
void display();

int main(){
    int data, choice, pos;
    printf("1. Insert\n2. Delete\n3. Exit\nChoice: ");
    scanf("%d", &choice);
    while(choice != 3){
        if (choice == 1){
            printf("Enter data: ");
            scanf("%d", &data);
            insert(data);
            printf("Count: %d\n", count);
        } else if (choice == 2){
            printf("Integer popped = %d\n", delete());
            printf("Count: %d\n", count);
        }
        display();
        printf("Enter choice: ");
        scanf("%d", &choice);
    }

    return 0;
}

void insert(int data){
    node* new_node = malloc(sizeof(node));
```

```

new_node->data = data;
new_node->next = NULL;
if (head == NULL){
    head = new_node;
    count++;
    return;
}
node* temp = head;
while(temp->next != NULL)
    temp = temp->next;
temp->next = new_node;
count++;
return;

}

int delete(){
    node* temp = head;
    head = head->next;
    int t = temp->data;
    free(temp);
    count--;
    return t;

}

void display(){
    node* temp = head;
    printf("Queue: ");
    while (temp->next != NULL){
        printf("%d ", temp->data);
        temp = temp->next;
    }
    printf("%d ", temp->data);
    printf("\n");
}

```

Output:

```
1. Insert
2. Delete
3. Exit
Choice: 1
Enter data: 1
Count: 1
Queue: 1
Enter choice: 1
Enter data: 2
Count: 2
Queue: 1 2
Enter choice: 1
Enter data: 3
Count: 3
Queue: 1 2 3
Enter choice: 2
Integer popped = 1
Count: 2
Queue: 2 3
Enter choice: 2
Integer popped = 2
Count: 1
Queue: 3
Enter choice: 3

Process returned 0 (0x0)   execution time : 8.781 s
Press any key to continue.
```

Lab 7

WAP to Implement doubly link list with primitive operations

- Create a doubly linked list.
- Insert a new node to the left of the node.
- Delete the node based on a specific value
- Display the contents of the list

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>

typedef struct Node{
    int data;
    struct Node *next;
    struct Node *prev;
} node;
```

```

node* head = NULL;
int count = 0;

void insert(int data, int position);
void delete(int element);
void display();

int main(){
    int data, choice, pos;
    printf("1. Insert\n2. Delete\n3. Exit\nChoice: ");
    scanf("%d", &choice);
    while(choice != 3){
        if (choice == 1){
            printf("Enter data and position: ");
            scanf("%d%d", &data, &pos);
            insert(data, pos);
            printf("Count: %d\n", count);
        } else if (choice == 2){
            printf("Enter element: ");
            scanf("%d", &pos);
            delete(pos);
            printf("Count: %d\n", count);
        }
        display();
        printf("Enter choice: ");
        scanf("%d", &choice);
    }

    return 0;
}

void insert(int data, int position){
    if (position == 0){
        node* new_node = malloc(sizeof(node));
        new_node->data = data;
        new_node->next = head;
        new_node->prev = NULL;
        if (head != NULL) head->prev = new_node;
        head = new_node;
        count++;
        return;
    }
}

```

```

} else if (position == count){
    node* new_node = malloc(sizeof(node));
    new_node->data = data;
    new_node->next = NULL;
    node* temp = head;
    while(temp->next != NULL)
        temp = temp->next;
    temp->next = new_node;
    new_node->prev = temp;
    count++;
    return;

} else if (position > count || position < 0){
    printf("Unable to insert at given position\n");
    return;
} else {
    node* temp = head;
    for(int i = 0; i < position-1; i++)
        temp = temp->next;
    node* new_node = malloc(sizeof(node));
    new_node->data = data;
    new_node->next = temp->next;
    new_node->prev = temp;
    temp->next->prev = new_node;
    temp->next = new_node;
    count++;
    return;
}
}

void delete(int element){
    int position = 0; node *temp = head;
    if (head == NULL){
        printf("List is empty, cannot delete"); return;
    }
    for(; position < count; temp=temp->next, position++){
        if (temp->data == element) break;
    }
    if (temp == NULL){
        printf("Element does not exist in list"); return;
    }
    if (position == 0){
        node* temp = head;

```

```

        temp = temp->next;
        temp->prev = NULL;
        free(head);
        head = temp;
        count--;
        return;
    } else if (position == count-1){
        node* temp = head;
        for(int i = 1; i < count-1; i++)
            temp = temp->next;
        node* temp1 = temp->next;
        temp->next = NULL;
        free(temp1);
        count--;
        return;
    } else if (position > count || position < 0){
        printf("Unable to delete at position\n");
        return;
    } else {
        node* temp = head;
        for(int i = 0; i < position; i++)
            temp = temp->next;
        temp->next->prev = temp->prev;
        temp->prev->next = temp->next;
        free(temp);
        count--;
        return;
    }
}

void display(){
    node* temp = head;
    printf("Linked List: ");
    while (temp->next != NULL){
        printf("%d ", temp->data);
        temp = temp->next;
    }
    printf("%d ", temp->data);
    printf("\n");
}

```


Output:

```
1. Insert
2. Delete
3. Exit
Choice: 1
Enter data and position: 1 0
Count: 1
Linked List: 1
Enter choice: 1
Enter data and position: 2 1
Count: 2
Linked List: 1 2
Enter choice: 1
Enter data and position: 3 2
Count: 3
Linked List: 1 2 3
Enter choice: 1
Enter data and position: 4 1
Count: 4
Linked List: 1 4 2 3
Enter choice: 2
Enter element: 4
Count: 3
Linked List: 1 2 3
Enter choice: 2
Enter element: 3
Count: 2
Linked List: 1 2
Enter choice: 2
Enter element: 1
Count: 1
Linked List: 2
Enter choice: 3

Process returned 0 (0x0)   execution time : 25.328 s
Press any key to continue.
```

Leetcode

Given the head of a singly linked list and an integer k, split the linked list into k consecutive linked list parts.

The length of each part should be as equal as possible: no two parts should have a size differing by more than one. This may lead to some parts being null.

The parts should be in the order of occurrence in the input list, and parts occurring earlier should always have a size greater than or equal to parts occurring later.

Return an array of the k parts.

Code:

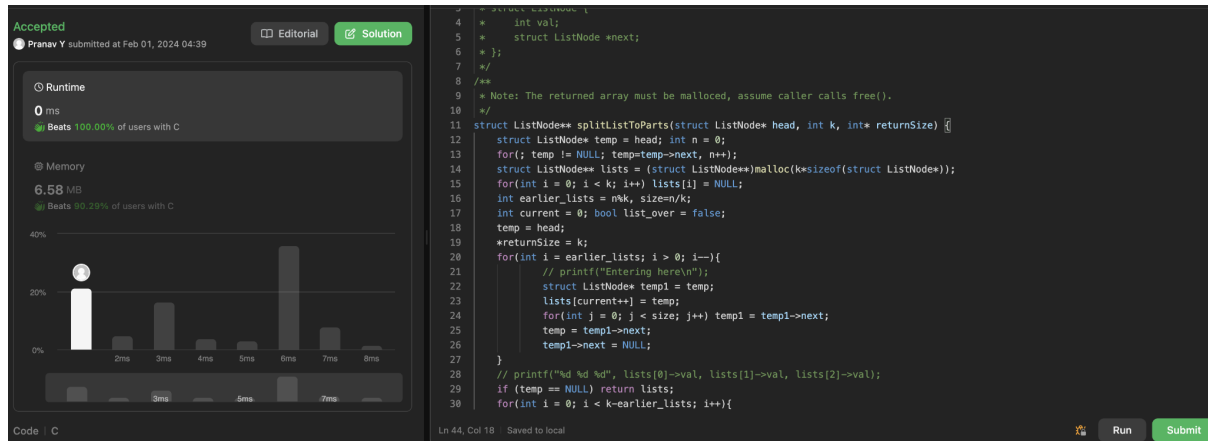
```
struct ListNode** splitListToParts(struct ListNode* head, int k,
```

```

int* returnSize) {
    struct ListNode* temp = head; int n = 0;
    for(; temp != NULL; temp=temp->next, n++);
    struct ListNode** lists = (struct
ListNode**)malloc(k*sizeof(struct ListNode*));
    for(int i = 0; i < k; i++) lists[i] = NULL;
    int earlier_lists = n%k, size=n/k;
    int current = 0; bool list_over = false;
    temp = head;
    *returnSize = k;
    for(int i = earlier_lists; i > 0; i--){
        // printf("Entering here\n");
        struct ListNode* temp1 = temp;
        lists[current++] = temp;
        for(int j = 0; j < size; j++) temp1 = temp1->next;
        temp = temp1->next;
        temp1->next = NULL;
    }
    // printf("%d %d %d", lists[0]->val, lists[1]->val,
lists[2]->val);
    if (temp == NULL) return lists;
    for(int i = 0; i < k-earlier_lists; i++){
        struct ListNode* temp1 = temp;
        if (temp1 == NULL) break;
        for(int j = 0; j < size-1; j++) temp1 = temp1->next;
        lists[current++] = temp;
        temp = temp1->next;
        temp1->next = NULL;
        // for(int l = 0; l < k; l++){
        //     for(struct ListNode* temp2 = lists[l]; temp2 !=
NULL; temp2 = temp2->next){
            //         printf("%d ", temp2->val);
            //     }
            //     printf("\n");
            // }
    }
    return lists;
}

```

Output:



Lab 8

Write a program

- To construct a binary Search tree.
- To traverse the tree using all the methods i.e., in-order, preorder and post order
- To display the elements in the tree.

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>
```

```
typedef struct Node{
    int data;
    struct Node *left;
    struct Node *right;
} node;
```

```
node *root = NULL;
```

```
void insert(node **root, int data);
void preorder(node **root);
void postorder(node **root);
void inorder(node **root);
```

```
int main(){
    int choice, data;
    insert(&root, 100);
    insert(&root, 20);
    insert(&root, 200);
    insert(&root, 10);
```

```

insert(&root, 30);
insert(&root, 150);
insert(&root, 300);
printf("1. Preorder\n2. Inorder\n3. Postorder\n4.
Exit\nChoice: ");
scanf("%d", &choice);
while (choice != 4){
    if (choice == 1){
        preorder(&root);
        printf("\n");
    } else if (choice == 2){
        inorder(&root);
        printf("\n");
    } else if (choice == 3){
        postorder(&root);
        printf("\n");
    }
    printf("Enter choice: ");
    scanf("%d", &choice);
}
}

```

```

void insert(node **root, int data){
    if (*root == NULL) {
        node *new_node = malloc(sizeof(node));
        new_node->data = data;
        new_node->right = NULL;
        new_node->left = NULL;
        *root = new_node;
        return;
    }
    if (data < (*root)->data){
        insert(&((*root)->left), data);
    } else if (data > (*root)->data){
        insert(&((*root)->right), data);
    }
    return;
}

```

```

void preorder(node **root){
    if (*root != NULL){
        printf("%d ", (*root)->data);
    }
}

```

```

        preorder(&((*root)->left));
        preorder(&((*root)->right));
    }
}

void postorder(node **root){
    if (*root != NULL){
        postorder(&((*root)->left));
        postorder(&((*root)->right));
        printf("%d ", (*root)->data);
    }
}

void inorder(node **root){
    if (*root != NULL) {
        inorder(&((*root)->left));
        printf("%d ", (*root)->data);
        inorder(&((*root)->right));
    }
}

```

Output:

```

1. Preorder
2. Inorder
3. Postorder
4. Exit
Choice: 1
100 20 10 30 200 150 300
Enter choice: 2
10 20 30 100 150 200 300
Enter choice: 3
10 30 20 150 300 200 100
Enter choice: 4

Process returned 0 (0x0)   execution time : 7.360 s
Press any key to continue.

```

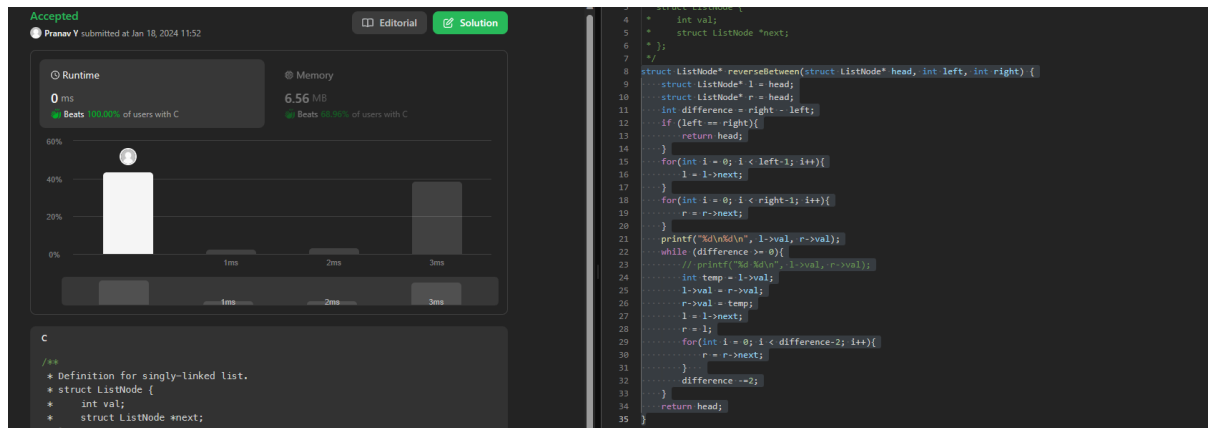
Leetcode

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

Code:

```
struct ListNode* rotateRight(struct ListNode* head, int k) {
    struct ListNode *temp = head;
    if (head == NULL) return NULL;
    if (head->next == NULL) return head;
    if (k == 0) return head;
    int size = 1;
    for(; temp->next != NULL; temp=temp->next, size++);
    k %= size;
    if (k == 0) return head;
    temp->next = head;
    struct ListNode *temp1 = head;
    for(int i = 0; i < (size-k-1); temp1 = temp1->next, i++);
    head = temp1->next;
    temp1->next = NULL;
    return head;
}
```

Output:



Lab 9

a) Write a program to traverse a graph using BFS method.

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>

#define size 7

void push(int a);
int pop();
void display();
void bfs(int graph[][7]);

int fpos = -1, rpos = -1;
int queue[size];

int main(){
    int adj_matrix[7][7] = {
        {0, 1, 0, 1, 0, 0, 0},
        {1, 0, 1, 1, 0, 1, 1},
        {0, 1, 0, 1, 1, 1, 0},
        {1, 1, 1, 0, 0, 0, 0},
        {0, 0, 1, 0, 0, 0, 1},
        {0, 1, 1, 0, 0, 0, 0},
        {0, 1, 0, 0, 1, 0, 0},
    };
    for(int i = 0; i < 7; i++) queue[i] = NULL;
    // display();
    bfs(adj_matrix);
    return 0;
}

void bfs(int graph[][7]){
    int visited[7];
    for(int i = 0; i < 7; i++) visited[i] = 0;
    push(0); visited[0] = 1;
    while (fpos != size){
        for(int i = 0; i < 7; i++){
            if(graph[queue[fpos]][i] == 1 && visited[i] != 1){
                push(i);
            }
        }
        fpos++;
    }
}
```

```

        visited[i] = 1;
        // break;
    }
}
printf("%d ", pop());
// printf("%d\n", new_node);
}
}

void push(int a){
    if (fpos == -1 && rpos == -1){
        queue[++rpos] = a;
        fpos++;
        return;
    }
    else if (rpos == size-1){
        printf("Queue overflow condition\n");
        return;
    }
    else{
        queue[++rpos] = a;
        return;
    }
}

int pop(){
    if (fpos == -1){
        printf("Queue Underflow condition\n");
    }
    int n = queue[fpos];
    queue[fpos] = (int) NULL;
    fpos++;
    return n;
}

void display(){
    printf("Queue: ");
    for(int i = 0; i < size; i++)
        printf("%d ", queue[i]);
    printf("\n");
}

```


Output:

```
● (base) pranavyadlapati@Pranavs-MacBook-Air DSLab % ./bfs
0 1 3 2 5 6 4 %
```

9b) Write a program to check whether given graph is connected or not using DFS method.

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>

#define size 7
int pos = -1;
int stack[size];

void push(int a);
int pop();
void display();
void dfs(int graph[][7]);

int main(){
    int adj_matrix[7][7] = {
        {0, 1, 0, 1, 0, 0, 0},
        {1, 0, 1, 1, 0, 1, 1},
        {0, 1, 0, 1, 1, 1, 0},
        {1, 1, 1, 0, 0, 0, 0},
        {0, 0, 1, 0, 0, 0, 1},
        {0, 1, 1, 0, 0, 0, 0},
        {0, 1, 0, 0, 1, 0, 0},
    };
    for(int i = 0; i < 7; i++) stack[i] = NULL;
    // display();
    dfs(adj_matrix);
    return 0;
}

void dfs(int graph[][7]){
    int visited[7];
    for (int i = 0; i < 7; i++) visited[i] = 0;
    push(0); visited[0] = 1; printf("0 ");
```

```

while(pos != -1){
    bool new_node = false;
    for(int i = 0; i < 7; i++){

        if(graph[stack[pos]][i] == 1 && visited[i] != 1){
            new_node = true;
            push(i);

            visited[i] = 1; printf("%d ", i);
            break;
        }
    }

    if (!new_node) pop();
}

}

void push(int a){
    if (pos == size-1){
        printf("Stack Overflow condition");
        return;
    }
    stack[++pos] = a;
}

int pop(){
    if (pos == -1){
        printf("Stack Underflow condition");
        return (int) NULL;
    }
    return stack[pos--];
}

void display(){
    for(int i = 0; i < size; i++){
        printf("%d ", stack[i]);
    }
    printf("\n");
}

```

Output:

```
(base) pranavyadlapati@Pranavs-MacBook-Air DSLab % ./dfs
0 1 2 3 4 6 5 %
```

Hackerrank Problem:

Given a tree and an integer, k , in one operation, we need to swap the subtrees of all the nodes at each depth h , where $h \in [k, 2k, 3k, \dots]$. In other words, if h is a multiple of k , swap the left and right subtrees of that level.

You are given a tree of n nodes where nodes are indexed from $[1..n]$ and it is rooted at 1. You have to perform t swap operations on it, and after each swap operation print the in-order traversal of the current state of the tree.

Code:

```
struct node {
    int data;
    struct node *left;
    struct node *right;
};

struct node* create_node(int val){
    if(val == -1){
        return NULL;
    }
    struct node *temp=(struct node*)malloc(sizeof(struct node));
    temp->data=val;
    temp->left=NULL;
    temp->right=NULL;
    return temp;
}

void inorder(struct node *root){
    if(!root){
        return;
    }
    inorder(root->left);
    printf("%d ", root->data);
    inorder(root->right);
}
```

```

int max(int a, int b){
    if(a>b){
        return a;
    } else {
        return b;
    }
}

int height(struct node * root){
    if(!root){
        return 0;
    }
    return(1+max(height(root->left),height(root->right)));
}

void swap_nodes_at_level(struct node *root, int inc, int level,
int height){
    struct node *tnode;
    if(!root){
        return;
    }
    if(level > height){
        return;
    }
    if(!(level%inc)){
        tnode=root->left;
        root->left=root->right;
        root->right=tnode;
    }
    swap_nodes_at_level(root->left, inc, level+1, height);
    swap_nodes_at_level(root->right, inc, level+1, height);
}

int tail=0;
int head=0;

void enqueue(struct node **queue, struct node *root){

    queue[tail]=root;
    tail++;
}

```

```

struct node* dequeue(struct node **queue){

    struct node *temp = queue[head];
    head++;
    return temp;
}

int main() {

    /* Enter your code here. Read input from STDIN. Print output
    to STDOUT */
    int nodes_count, i, temp, h, tc_num, index, inc, temp1, temp2;

    scanf("%d", &nodes_count);

    // printf("%d\n", nodes_count);

    // int arr[2*nodes_count+1];

    struct node *root_perm, *root_temp;

    //queue=create_queue(nodes_count);

    struct node *q[nodes_count];
    for(i=0;i<nodes_count;i++){
        q[i]=NULL;
    }

    //building the array

    i=0,index=1;
    root_temp=root_perm=create_node(1);
    enqueue(q, root_temp);

    while(index<=2*nodes_count) {

        //printf("\n In Loop : i : %d",i);
        root_temp=dequeue(q);
        //setting up the left child
        scanf("%d", &temp1);
        if(temp1 == -1){

```

```

    } else {
        root_temp->left=create_node(temp1);
        enqueue(q, root_temp->left);
    }
    //setting up the right child
    scanf("%d", &temp2);
    if(temp2== -1) {

    } else {
        root_temp->right=create_node(temp2);
        enqueue(q, root_temp->right);
    }
    index=index+2;
    // i++;

}

h = height(root_perm);

scanf("%d", &tc_num);

//printf("%d",tc_num);
//printf("\n");

//inorder(root_perm);


while(tc_num){
    scanf("%d",&inc);
    temp=inc;
    //while(temp < height){
    swap_nodes_at_level(root_perm, inc, 1, h);
    //temp=temp + inc;
    //}
    //temp=0;
    inorder(root_perm);
    printf("\n");
    tc_num--;
}

//Tree is created at this point

```

```
}    return 0;  
}
```

Output:



You have earned 40.00 points!
104/563 challenges solved.


18%

Congratulations

You solved this challenge. Would you like to challenge your friends? [f](#) [t](#) [in](#)


[Next Challenge](#)


✓ Test case 0


✓ Test case 1 

✓ Test case 2

✓ Test case 3

✓ Test case 4 

✓ Test case 5 

✓ Test case 6 

Compiler Message

Success

Input (stdin) [Download](#)

1	3
2	2 3
3	-1 -1
4	-1 -1
5	2
6	1
7	1

Lab 10:

Given a File of N employee records with a set K of Keys(4-digit) which uniquely determine the records in file F. Assume that file F is maintained in memory by a Hash Table (HT) of memory locations with L as the set of memory addresses (2-digit) of locations in HT. Let the keys in K and addresses in L are integers.

Design and develop a Program in C that uses Hash function H: $K \rightarrow L$ as $H(K) = K \bmod m$ (remainder method), and implement hashing technique to map a given key K to the address space L.

Resolve the collision (if any) using linear probing.

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>
#include <string.h>

#define size 10

int table[size];

void push(int data);
int pop(int data);
void search(int data);
void display();

int main(){
    for(int i = 0; i < size; i++) table[i] = -1;
    int choice;
    printf("1. Insert\n2. Search\n3. Delete\n4. Exit\nChoice: ");
    scanf("%d", &choice);
    int a;
    while(choice != 4){
        switch(choice){
            case 1:
                printf("Enter integer to be pushed: ");
                scanf("%d", &a);
                push(a);
                break;
            case 2:
                printf("Enter integer to be popped: ");
                scanf("%d", &a);
                int res = pop(a);
                if (res == 0) printf("Integer popped\n");
        }
    }
}
```



```

        else printf("Integer not found\n");
        break;
    case 3:
        display();
        break;
    default:
        printf("Idk");
        break;
    }
    printf("Enter choice: ");
    scanf("%d", &choice);
}
}

void push(int data){
    int hash = data%size;
    while (table[hash] != -1 && hash <= (hash+size-1)) hash =
(hash+1)%size;
    if (table[hash] == -1) table[hash] = data;
    else printf("Table is full");
}

int pop(int data){
    int hash = data%size;
    for(int i = 0; (table[hash] != data) || (i < size); i++, hash
= (hash+1)%size);
    if (table[hash] == data) {
        table[hash] = -1; return 0;
    }
    return -1;
}

void display(){
    printf("Table: ");
    for(int i = 0; i < size; i++)
        printf("%d ", table[i]);
    printf("\n");
}

```

Output:

```
1. Insert
2. Search
3. Delete
4. Exit
Choice: 1
Enter integer to be pushed: 1
Enter choice: 1
Enter integer to be pushed: 3
Enter choice: 1
Enter integer to be pushed: 90
Enter choice: 3
Table: 90 1 -1 3 -1 -1 -1 -1 -1 -1
Enter choice: 1
Enter integer to be pushed: 13
Enter choice: 3
Table: 90 1 -1 3 13 -1 -1 -1 -1 -1
Enter choice: 1
Enter integer to be pushed: 4
Enter choice: 3
Table: 90 1 -1 3 13 4 -1 -1 -1 -1
Enter choice: 4

Process returned 0 (0x0)   execution time : 45.082 s
Press any key to continue.
```