.

**Dept of Artificial Intelligence and Machine Learning** | **Rajalakshmi Engineering College** 1



DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

Laboratory Manual

REGULATION 2023

CS23231 – DATA STRUCTURES

**RAJALAKSHMI ENGINEERING COLLEGE**

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**An Autonomous Institution, Affiliated to Anna University Rajalakshmi Nagar, Thandalam – 602 105**



**DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING**

**LAB MANUAL**

**CS23231 – DATA STRUCTURES**

**(*Regulation 2023*)**

2116-231501015

Aniruth S V



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**LESSON PLAN**

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| **Course Code** | **Course Title**  **(Laboratory Integrated Theory Course)** | **L** | **T** | **P** | **C** |
| **CS23231** | **Data Structures** | **1** | **0** | **6** | **4** |

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| **LIST OF EXPERIMENTS** | |
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| Week 1 | Implementation of Single Linked List (Insertion, Deletion and Display) |
| Week 2 | Implementation of Doubly Linked List (Insertion, Deletion and Display) |
| Week 3 | Applications of Singly Linked List (Polynomial Manipulation) |
| Week 4 | Implementation of Stack using Array and Linked List implementation |
| Week 5 | Applications of Stack (Infix to Postfix) |
| Week 6 | Applications of Stack (Evaluating Arithmetic Expression) |
| Week 7 | Implementation of Queue using Array and Linked List implementation |
| Week 8 | Implementation of Binary Search Tree |
| Week 9 | Performing Tree Traversal Techniques |
| Week 10 | Implementation of AVL Tree |
| Week 11 | Performing Topological Sorting |
| Week 12 | Implementation of BFS, DFS |
| Week 13 | Implementation of Prim’s Algorithm |
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| Week 15 | Program to perform Sorting |
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| Week 17 | Implementation of Rehashing |

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| **Ex. No.: 1** | **Implementation of Single Linked List** | **Date: 23/2/24** |

**Write a C p r o g r a m t o i m p l e m e n t t h e f o l l o w i n g o p e r a t i o n s o n S i n g l y L i n k e d L i s t .**

1. **Insert a node in the beginning of a list.**
2. **Insert a node after P**
3. **Insert a node at the end of a list**
4. **Find an element in a list**
5. **FindNext**
6. **FindPrevious**
7. **isLast**
8. **isEmpty**
9. **Delete a node in the beginning of a list.**
10. **Delete a node after P**
11. **Delete a node at the end of a list**
12. **Delete the List Algorithm:**

#include <stdio.h> #include <malloc.h>

struct node {

int data;

struct node\* next;

};

struct node\* head = NULL; void insertfront(int ele) {

struct node\* newnode = (struct node\*)malloc(sizeof(struct node));

if (newnode != NULL) { newnode->data = ele; newnode->next = head; head = newnode;

}

}

void insertend(int ele) {

struct node\* newnode = (struct node\*)malloc(sizeof(struct node)); if (newnode != NULL) {

newnode->data = ele; newnode->next = NULL;

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if (head == NULL) { head = newnode;

} else {

struct node\* t = head; while (t->next != NULL) {

t = t->next;

}

t->next = newnode;

}

}

}

int listsize() { int count = 0;

struct node\* t = head; while (t != NULL) {

count++;

t = t->next;

}

return count;

}

void insertpos(int ele, int pos) { int ls = listsize();

if ((head == NULL && pos != 1) || pos <= 0 || pos > ls + 1) { printf("\nInvalid position to insert a node\n");

return;

}

struct node\* newnode = (struct node\*)malloc(sizeof(struct node)); if (newnode != NULL) {

newnode->data = ele; if (pos == 1) {

newnode->next = head; head = newnode;

} else {

struct node\* temp = head;

for (int count = 1; count < pos - 1; count++) { temp = temp->next;

}

newnode->next = temp->next; temp->next = newnode;

}

}

}

void findnext(int s) { struct node\* temp = head;

while (temp != NULL && temp->data != s) { temp = temp->next;

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}

if (temp != NULL && temp->next != NULL) {

printf("\nNext element of %d is %d\n", s, temp->next->data);

} else {

printf("\nNo next element for %d\n", s);

}

}

void findprev(int s) {

if (head == NULL || head->data == s) { printf("\nNo previous element for %d\n", s); return;

}

struct node\* temp = head;

while (temp->next != NULL && temp->next->data != s) { temp = temp->next;

}

if (temp->next != NULL) {

printf("\nPrevious element of %d is %d\n", s, temp->data);

} else {

printf("\nElement %d not found\n", s);

}

}

void find(int s) {

struct node\* temp = head;

while (temp != NULL && temp->data != s) { temp = temp->next;

}

if (temp != NULL) {

printf("\nElement %d is present in the list\n", s);

} else {

printf("\nElement %d is not present in the list\n", s);

}

}

void isempty() {

if (head == NULL) { printf("\nList is empty\n");

} else {

printf("\nList is not empty\n");

}

}

void deleteAtBeginning() { if (head != NULL) {

struct node\* temp = head; head = head->next; free(temp);

}

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}

void deleteAtEnd() { if (head == NULL) {

printf("\nList is empty\n"); return;

}

if (head->next == NULL) { free(head);

head = NULL;

} else {

struct node\* temp = head;

while (temp->next->next != NULL) { temp = temp->next;

}

free(temp->next); temp->next = NULL;

}

}

void delete(int ele) { if (head == NULL) {

printf("\nList is empty\n"); return;

}

if (head->data == ele) { struct node\* temp = head; head = head->next; free(temp);

} else {

struct node\* temp = head;

while (temp->next != NULL && temp->next->data != ele) { temp = temp->next;

}

if (temp->next != NULL) {

struct node\* delNode = temp->next; temp->next = temp->next->next; free(delNode);

} else {

printf("\nElement %d not found\n", ele);

}

}

}

void display() {

struct node\* t = head; while (t != NULL) {

printf("%d\t", t->data); t = t->next;

}

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printf("\n");

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}

int main() {

insertfront(5); insertfront(10); insertfront(20); insertend(30); insertend(40); display();

printf("\nAfter inserting 15 at the 2nd position\n"); insertpos(15, 2);

display();

findnext(30); findprev(30);

find(15); isempty();

printf("\nAfter deleting the first element\n"); deleteAtBeginning();

display();

printf("\nAfter deleting the last element\n"); deleteAtEnd();

display();

printf("\nAfter deleting element 15\n"); delete(15);

display();

return 0;

}

|  |  |  |
| --- | --- | --- |
| **Ex. No.: 2** | **Implementation of Doubly Linked List** | **Date: 11/3/24** |

**Write a C p r o g r a m t o i m p l e m e n t t h e f o l l o w i n g o p e r a t i o n s o n D o u b l y L i n k e d L i s t .**

1. **Insertion**
2. **Deletion**
3. **Search**
4. **Display**

**Algorithm:**

#include <stdio.h> #include <malloc.h>

struct node {

int data;

struct node\* next; struct node\* prev;

};

struct node\* head = NULL; void insertfront(int ele) {

struct node\* newnode = (struct node\*)malloc(sizeof(struct node)); if (newnode != NULL) {

newnode->data = ele; newnode->next = head; newnode->prev = NULL; if (head != NULL) {

head->prev = newnode;

}

head = newnode;

}

}

void insertend(int ele) {

struct node\* newnode = (struct node\*)malloc(sizeof(struct node)); if (newnode != NULL) {

newnode->data = ele; newnode->next = NULL; if (head == NULL) {

newnode->prev = NULL; head = newnode;

} else {

struct node\* t = head; while (t->next != NULL) {

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t = t->next;

}

t->next = newnode; newnode->prev = t;

}

}

}

int listsize() { int count = 0;

struct node\* t = head; while (t != NULL) {

count++;

t = t->next;

}

return count;

}

void insertpos(int ele, int pos) { int ls = listsize();

if ((head == NULL && pos != 1) || pos <= 0 || pos > ls + 1) { printf("\nInvalid position to insert a node\n");

return;

}

struct node\* newnode = (struct node\*)malloc(sizeof(struct node)); if (newnode != NULL) {

newnode->data = ele; if (pos == 1) {

newnode->next = head; newnode->prev = NULL; if (head != NULL) {

head->prev = newnode;

}

head = newnode;

} else {

struct node\* temp = head;

for (int count = 1; count < pos - 1; count++) { temp = temp->next;

}

newnode->next = temp->next; newnode->prev = temp;

if (temp->next != NULL) {

temp->next->prev = newnode;

}

temp->next = newnode;

}

}

}

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void findnext(int s) { struct node\* temp = head;

while (temp != NULL && temp->data != s) { temp = temp->next;

}

if (temp != NULL && temp->next != NULL) {

printf("\nNext element of %d is %d\n", s, temp->next->data);

} else {

printf("\nNo next element for %d\n", s);

}

}

void findprev(int s) { struct node\* temp = head;

while (temp != NULL && temp->data != s) { temp = temp->next;

}

if (temp != NULL && temp->prev != NULL) {

printf("\nPrevious element of %d is %d\n", s, temp->prev->data);

} else {

printf("\nNo previous element for %d\n", s);

}

}

void find(int s) {

struct node\* temp = head;

while (temp != NULL && temp->data != s) { temp = temp->next;

}

if (temp != NULL) {

printf("\nElement %d is present in the list\n", s);

} else {

printf("\nElement %d is not present in the list\n", s);

}

}

void isempty() {

if (head == NULL) { printf("\nList is empty\n");

} else {

printf("\nList is not empty\n");

}

}

void deleteAtBeginning() { if (head != NULL) {

struct node\* temp = head; head = head->next;

if (head != NULL) { head->prev = NULL;

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}

free(temp);

}

}

void deleteAtEnd() { if (head == NULL) {

printf("\nList is empty\n"); return;

}

if (head->next == NULL) { free(head);

head = NULL;

} else {

struct node\* temp = head; while (temp->next != NULL) {

temp = temp->next;

}

temp->prev->next = NULL; free(temp);

}

}

void delete(int ele) { if (head == NULL) {

printf("\nList is empty\n"); return;

}

if (head->data == ele) { struct node\* temp = head; head = head->next;

if (head != NULL) { head->prev = NULL;

}

free(temp);

} else {

struct node\* temp = head;

while (temp != NULL && temp->data != ele) { temp = temp->next;

}

if (temp != NULL) {

if (temp->prev != NULL) {

temp->prev->next = temp->next;

}

if (temp->next != NULL) {

temp->next->prev = temp->prev;

}

free(temp);

} else {

printf("\nElement %d not found\n", ele);

.

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}

}

}

void display() {

struct node\* t = head; while (t != NULL) {

printf("%d\t", t->data); t = t->next;

}

printf("\n");

}

int main() {

insertfront(5); insertfront(10); insertfront(20); insertend(30); insertend(40); display();

printf("\nAfter inserting 15 at the 2nd position\n"); insertpos(15, 2);

display();

findnext(30); findprev(30);

find(15); isempty();

printf("\nAfter deleting the first element\n"); deleteAtBeginning();

display();

printf("\nAfter deleting the last element\n"); deleteAtEnd();

display();

printf("\nAfter deleting element 15\n"); delete(15);

display();

return 0;

}

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| --- | --- | --- |
| **Ex. No.: 3** | **Polynomial Manipulation** | **Date: 8/3/24** |

**Write a C p r o g r a m t o i m p l e m e n t t h e f o l l o w i n g o p e r a t i o n s o n S i n g l y L i n k e d L i s t .**

1. **Polynomial Addition**
2. **Polynomial Subtraction**
3. **Polynomial Multiplication**

**Algorithm:**

#include <stdio.h> #include <malloc.h>

struct node {

int coeff; int exp;

struct node\* next; struct node\* prev;

};

struct node\* head1 = NULL; struct node\* head2 = NULL; struct node\* headResult = NULL;

void insertTerm(struct node\*\* head, int coeff, int exp) {

struct node\* newnode = (struct node\*)malloc(sizeof(struct node)); if (newnode != NULL) {

newnode->coeff = coeff; newnode->exp = exp; newnode->next = NULL; newnode->prev = NULL; if (\*head == NULL) {

\*head = newnode;

} else {

struct node\* t = \*head; while (t->next != NULL) {

t = t->next;

}

t->next = newnode; newnode->prev = t;

}

}

}

void display(struct node\* head) { struct node\* t = head;

while (t != NULL) {

if (t->coeff > 0 && t != head)

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printf("+ ");

printf("%dx^%d ", t->coeff, t->exp); t = t->next;

}

printf("\n");

}

struct node\* addPolynomials(struct node\* head1, struct node\* head2) { struct node\* result = NULL;

struct node\* t1 = head1; struct node\* t2 = head2;

while (t1 != NULL && t2 != NULL) { if (t1->exp == t2->exp) {

insertTerm(&result, t1->coeff + t2->coeff, t1->exp); t1 = t1->next;

t2 = t2->next;

} else if (t1->exp > t2->exp) { insertTerm(&result, t1->coeff, t1->exp); t1 = t1->next;

} else {

insertTerm(&result, t2->coeff, t2->exp); t2 = t2->next;

}

}

while (t1 != NULL) {

insertTerm(&result, t1->coeff, t1->exp); t1 = t1->next;

}

while (t2 != NULL) {

insertTerm(&result, t2->coeff, t2->exp); t2 = t2->next;

}

return result;

}

struct node\* multiplyPolynomials(struct node\* head1, struct node\* head2) { struct node\* result = NULL;

struct node\* t1 = head1; struct node\* t2 = head2;

while (t1 != NULL) { t2 = head2;

while (t2 != NULL) {

insertTerm(&result, t1->coeff \* t2->coeff, t1->exp + t2->exp); t2 = t2->next;

}

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t1 = t1->next;

}

struct node\* t = result; struct node\* tPrev = NULL;

while (t != NULL && t->next != NULL) { tPrev = t;

struct node\* tNext = t->next; while (tNext != NULL) {

if (t->exp == tNext->exp) { t->coeff += tNext->coeff;

tPrev->next = tNext->next; if (tNext->next != NULL) {

tNext->next->prev = tPrev;

}

free(tNext);

tNext = tPrev->next;

} else {

tPrev = tNext;

tNext = tNext->next;

}

}

t = t->next;

}

return result;

}

int main() {

insertTerm(&head1, 5, 2);

insertTerm(&head1, 4, 1);

insertTerm(&head1, 2, 0);

insertTerm(&head2, 5, 1);

insertTerm(&head2, 5, 0);

printf("Polynomial 1: "); display(head1);

printf("Polynomial 2: "); display(head2);

headResult = addPolynomials(head1, head2); printf("\nAddition Result: "); display(headResult);

headResult = multiplyPolynomials(head1, head2); printf("\nMultiplication Result: "); display(headResult);

return 0;}

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| --- | --- | --- |
| **Ex. No.: 4** | **Implementation of Stack using Array and Linked List Implementation** | **Date: 15/3/24** |

**Write a C p r o g r a m t o i m p l e m e n t a s t a c k u s i n g A r r a y a n d l i n k e d L i s t i m p l e m e n t a t i o n a n d e x e c u t e t h e f o l l o w i n g o p e r a t i o n o n s t a c k .**

1. **Push an element into a stack**
2. **Pop an element from a stack**
3. **Return the Top most element from a stack**
4. **Display the elements in a stack**

**Algorithm:**

#include <stdio.h> #include <malloc.h>

struct node {

int data;

struct node\* next;

};

struct node\* top = NULL; void push(int ele) {

struct node\* newnode = (struct node\*)malloc(sizeof(struct node));

if (newnode != NULL) { newnode->data = ele; newnode->next = top; top = newnode;

}

}

int pop() {

if (top == NULL) { printf("\nStack Underflow\n"); return -1;

} else {

int popped = top->data; struct node\* temp = top; top = top->next; free(temp);

return popped;

}

}

int peek() {

if (top != NULL) { return top->data;

} else {

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printf("\nStack is empty\n"); return -1;

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}

}

int isEmpty() {

return top == NULL;

}

void display() {

struct node\* t = top; while (t != NULL) {

printf("%d\t", t->data); t = t->next;

}

printf("\n");

}

int main() {

push(10);

push(20);

push(30); display();

printf("Top element is %d\n", peek());

printf("Popped element is %d\n", pop()); display();

printf("Popped element is %d\n", pop()); display();

printf("Is stack empty? %s\n", isEmpty() ? "Yes" : "No"); printf("Popped element is %d\n", pop());

display();

printf("Is stack empty? %s\n", isEmpty() ? "Yes" : "No");

return 0;

}

|  |  |  |
| --- | --- | --- |
| **Ex. No.: 5** | **Infix to Postfix Conversion** | **Date:5/4/24** |

**Write a C p r o g r a m t o p e r f o r m i n f i x t o p o s t f i x c o n v e r s i o n u s i n g s t a c k . Algorithm:**

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

struct node {

char data;

struct node\* next;

};

struct node\* top = NULL; void push(char ele) {

struct node\* newnode = (struct node\*)malloc(sizeof(struct node)); if (newnode != NULL) {

newnode->data = ele; newnode->next = top; top = newnode;

}

}

char pop() {

if (top == NULL) { printf("\nStack Underflow\n"); return -1;

} else {

char popped = top->data; struct node\* temp = top; top = top->next; free(temp);

return popped;

}

}

char peek() {

if (top != NULL) { return top->data;

} else {

return -1;

}

}

int isEmpty() {

return top == NULL;

}

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int precedence(char op) { switch (op) {

case '+':

case '-': return 1; case '\*':

case '/': return 2; case '^': return 3; default: return 0;

}

}

int isOperator(char ch) {

return ch == '+' || ch == '-' || ch == '\*' || ch == '/' || ch == '^';

}

void infixToPostfix(char\* infix, char\* postfix) { int i = 0, j = 0;

while (infix[i] != '\0') {

if (isdigit(infix[i]) || isalpha(infix[i])) { postfix[j++] = infix[i];

} else if (infix[i] == '(') { push(infix[i]);

} else if (infix[i] == ')') {

while (!isEmpty() && peek() != '(') { postfix[j++] = pop();

}

pop(); // Remove '(' from stack

} else if (isOperator(infix[i])) {

while (!isEmpty() && precedence(peek()) >= precedence(infix[i])) { postfix[j++] = pop();

}

push(infix[i]);

}

i++;

}

while (!isEmpty()) { postfix[j++] = pop();

}

postfix[j] = '\0';

}

int main() {

char infix[100] = "a+b\*(c^d-e)^(f+g\*h)-i"; char postfix[100];

printf("Infix expression: %s\n", infix); infixToPostfix(infix, postfix); printf("Postfix expression: %s\n", postfix);

return 0;

}

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| --- | --- | --- |
| **Ex. No.: 6** | **Evaluating Arithmetic Expression** | **Date: 12/4/24** |

**Write a C p r o g r a m t o e v a l u a t e A r i t h m e t i c e x p r e s s i o n u s i n g s t a c k . Algorithm:**

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

struct node {

int data;

struct node\* next;

};

struct node\* top = NULL; void push(int ele) {

struct node\* newnode = (struct node\*)malloc(sizeof(struct node));

if (newnode != NULL) { newnode->data = ele; newnode->next = top; top = newnode;

}

}

int pop() {

if (top == NULL) { printf("\nStack Underflow\n"); return -1;

} else {

int popped = top->data; struct node\* temp = top; top = top->next; free(temp);

return popped;

}

}

int isEmpty() {

return top == NULL;

}

int evaluatePostfix(char\* expression) { int i = 0;

while (expression[i] != '\0') { if (isdigit(expression[i])) {

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push(expression[i] - '0');

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} else {

int val1 = pop(); int val2 = pop();

switch (expression[i]) {

case '+': push(val2 + val1); break; case '-': push(val2 - val1); break; case '\*': push(val2 \* val1); break; case '/': push(val2 / val1); break;

}

} i++;

}

return pop();

}

int main() {

char postfix[100] = "53+62/\*35\*+"; printf("Postfix expression: %s\n", postfix); int result = evaluatePostfix(postfix); printf("Evaluation result: %d\n", result);

return 0;

}

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| --- | --- | --- |
| **Ex. No.: 7** | **Implementation of Queue using Array and Linked List Implementation** | **Date: 19/ 4/24** |

**Write a C p r o g r a m t o i m p l e m e n t a Q u e u e u s i n g A r r a y a n d l i n k e d L i s t i m p l e m e n t a t i o n a n d e x e c u t e t h e f o l l o w i n g o p e r a t i o n o n s t a c k .**

1. **Enqueue**
2. **Dequeue**
3. **Display the elements in a Queue**

**Algorithm:** #include <stdio.h> #include <stdlib.h>

struct node {

int data;

struct node\* next;

};

struct node\* head = NULL; struct node\* tail = NULL;

void enqueue(int ele) {

struct node\* newnode = (struct node\*)malloc(sizeof(struct node)); if (newnode != NULL) {

newnode->data = ele; newnode->next = NULL; if (tail == NULL) {

head = tail = newnode;

} else {

tail->next = newnode; tail = newnode;

}

}

}

int dequeue() {

if (head == NULL) { printf("\nQueue Underflow\n"); return -1;

} else {

int dequeued = head->data; struct node\* temp = head; head = head->next;

if (head == NULL) { tail = NULL;

}

free(temp); return dequeued;

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}

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}

int isEmpty() {

return head == NULL;

}

void display() {

struct node\* t = head; while (t != NULL) {

printf("%d\t", t->data); t = t->next;

}

printf("\n");

}

int main() {

enqueue(10); enqueue(20); enqueue(30); display();

printf("Dequeued element: %d\n", dequeue()); display();

printf("Dequeued element: %d\n", dequeue()); display();

printf("Is queue empty? %s\n", isEmpty() ? "Yes" : "No"); enqueue(40);

display();

printf("Is queue empty? %s\n", isEmpty() ? "Yes" : "No");

return 0;

}

|  |  |  |
| --- | --- | --- |
| **Ex. No.: 8** | **Tree Traversal** | **Date: 17/5/24** |

**Write a C p r o g r a m t o i m p l e m e n t a B i n a r y t r e e a n d p e r f o r m t h e f o l l o w i n g t r e e t r a v e r s a l o p e r a t i o n .**

1. **Inorder Traversal**
2. **Preorder Traversal**
3. **Postorder Traversal Algorithm:**

#include <stdio.h> #include <malloc.h> struct node {

int data;

struct node\* left; struct node\* right;

};

struct node\* root = NULL; struct node\* newnode;

void insert(int ele) {

newnode = (struct node\*)malloc(sizeof(struct node)); newnode->data = ele;

newnode->left = newnode->right = NULL;

if (root == NULL) { root = newnode;

} else {

struct node\* current = root; struct node\* parent = NULL;

while (1) {

parent = current;

if (ele < parent->data) { current = current->left; if (current == NULL) {

parent->left = newnode; return;

}

} else {

current = current->right; if (current == NULL) {

parent->right = newnode; return;

}

}

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}

}

}

void inorder(struct node\* t) { if (root == NULL) return; if (t != NULL) {

inorder(t->left); printf("%d ", t->data); inorder(t->right);

}

}

void preorder(struct node\* t) { if (root == NULL) return; if (t != NULL) {

printf("%d ", t->data); preorder(t->left); preorder(t->right);

}

}

void postorder(struct node\* t) { if (root == NULL) return; if (t != NULL) {

postorder(t->left); postorder(t->right); printf("%d ", t->data);

}

}

int main() {

insert(5); insert(3); insert(7); insert(2); insert(4); insert(6); insert(8);

printf("Inorder Traversal: "); inorder(root);

printf("\n");

printf("Preorder Traversal: "); preorder(root);

printf("\n");

printf("Postorder Traversal: "); postorder(root);

printf("\n");

return 0;

}

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| **Ex. No.: 9** | **Implementation of Binary Search tree** | **Date: 17/5/24** |

**Write a C p r o g r a m t o i m p l e m e n t a B i n a r y S e a r c h T r e e a n d p e r f o r m t h e f o l l o w i n g o p e r a t i o n s .**

1. **Insert**
2. **Delete**
3. **Search**
4. **Display Algorithm:**

#include <stdio.h> #include <stdlib.h> struct node {

int data;

struct node\* left; struct node\* right;

};

struct node\* createNode(int data) {

struct node\* newNode = (struct node\*)malloc(sizeof(struct node)); if (newNode != NULL) {

newNode->data = data; newNode->left = NULL; newNode->right = NULL;

}

return newNode;

}

struct node\* insert(struct node\* root, int data) { if (root == NULL) {

return createNode(data);

}

if (data < root->data) {

root->left = insert(root->left, data);

} else if (data > root->data) {

root->right = insert(root->right, data);

}

return root;

}

struct node\* search(struct node\* root, int data) { if (root == NULL || root->data == data) {

return root;

}

if (data < root->data) {

return search(root->left, data);

}

return search(root->right, data);

}

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struct node\* findMin(struct node\* root) { while (root->left != NULL) {

root = root->left;

}

return root;

}

struct node\* deleteNode(struct node\* root, int data) { if (root == NULL) {

return root;

}

if (data < root->data) {

root->left = deleteNode(root->left, data);

} else if (data > root->data) {

root->right = deleteNode(root->right, data);

} else {

if (root->left == NULL) {

struct node\* temp = root->right; free(root);

return temp;

} else if (root->right == NULL) { struct node\* temp = root->left; free(root);

return temp;

}

struct node\* temp = findMin(root->right); root->data = temp->data;

root->right = deleteNode(root->right, temp->data);

}

return root;

}

void inorder(struct node\* root) { if (root != NULL) {

inorder(root->left); printf("%d\t", root->data); inorder(root->right);

}

}

void preorder(struct node\* root) { if (root != NULL) {

printf("%d\t", root->data); preorder(root->left); preorder(root->right);

}

}

void postorder(struct node\* root) { if (root != NULL) {

postorder(root->left); postorder(root->right); printf("%d\t", root->data);

}

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}

int main() {

struct node\* root = NULL; root = insert(root, 50); insert(root, 30);

insert(root, 70);

insert(root, 20);

insert(root, 40);

insert(root, 60);

insert(root, 80);

printf("Inorder traversal: "); inorder(root);

printf("\n");

printf("Preorder traversal: "); preorder(root);

printf("\n");

printf("Postorder traversal: "); postorder(root);

printf("\n");

int key = 40;

if (search(root, key) != NULL) {

printf("Element %d found in the BST\n", key);

} else {

printf("Element %d not found in the BST\n", key);

}

printf("Deleting 20\n"); root = deleteNode(root, 20);

printf("Inorder traversal after deletion: "); inorder(root);

printf("\n"); printf("Deleting 30\n"); root = deleteNode(root, 30);

printf("Inorder traversal after deletion: "); inorder(root);

printf("\n");

printf("Deleting 50\n"); root = deleteNode(root, 50);

printf("Inorder traversal after deletion: "); inorder(root);

printf("\n");

return 0;

}

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| **Ex. No.: 10** | **Implementation of AVL Tree** | **Date: 24/5/24** |

**Write a f u n c t i o n i n C p r o g r a m t o i n s e r t a n e w n o d e w i t h a g i v e n v a l u e i n t o a n A V L t r e e . E n s u r e t h a t t h e t r e e r e m a i n s b a l a n c e d a f t e r i n s e r t i o n b y p e r f o r m i n g r o t a t i o n s i f n e c e s s a r y . R e p e a t t h e a b o v e o p e r a t i o n t o d e l e t e a n o d e f r o m A V L t r e e .**

**Algorithm:** #include <stdio.h> #include <malloc.h>

struct node {

int data;

struct node\* left; struct node\* right; int height;

};

struct node\* root = NULL; struct node\* newnode;

int height(struct node\* N) { if (N == NULL) return 0; return N->height;

}

int max(int a, int b) { return (a > b) ? a : b;

}

struct node\* rightRotate(struct node\* y) { struct node\* x = y->left;

struct node\* T2 = x->right; x->right = y;

y->left = T2;

y->height = max(height(y->left), height(y->right)) + 1; x->height = max(height(x->left), height(x->right)) + 1; return x;

}

struct node\* leftRotate(struct node\* x) { struct node\* y = x->right;

struct node\* T2 = y->left; y->left = x;

x->right = T2;

x->height = max(height(x->left), height(x->right)) + 1; y->height = max(height(y->left), height(y->right)) + 1; return y;

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}

int getBalance(struct node\* N) { if (N == NULL) return 0;

return height(N->left) - height(N->right);

}

struct node\* insert(struct node\* node, int ele) { if (node == NULL) {

newnode = (struct node\*)malloc(sizeof(struct node)); newnode->data = ele;

newnode->left = newnode->right = NULL; newnode->height = 1;

return newnode;

}

if (ele < node->data) {

node->left = insert(node->left, ele);

} else if (ele > node->data) {

node->right = insert(node->right, ele);

} else {

return node;

}

node->height = 1 + max(height(node->left), height(node->right)); int balance = getBalance(node);

if (balance > 1 && ele < node->left->data) return rightRotate(node); if (balance < -1 && ele > node->right->data) return leftRotate(node); if (balance > 1 && ele > node->left->data) {

node->left = leftRotate(node->left); return rightRotate(node);

}

if (balance < -1 && ele < node->right->data) { node->right = rightRotate(node->right); return leftRotate(node);

}

return node;

}

void inorder(struct node\* t) { if (root == NULL) return; if (t != NULL) {

inorder(t->left); printf("%d ", t->data); inorder(t->right);

}

}

void preorder(struct node\* t) { if (root == NULL) return; if (t != NULL) {

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printf("%d ", t->data); preorder(t->left); preorder(t->right);

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}

}

void postorder(struct node\* t) { if (root == NULL) return; if (t != NULL) {

postorder(t->left); postorder(t->right); printf("%d ", t->data);

}

}

int main() {

root = insert(root, 10); root = insert(root, 20); root = insert(root, 30); root = insert(root, 40); root = insert(root, 50); root = insert(root, 25);

printf("Inorder Traversal: "); inorder(root);

printf("\n");

printf("Preorder Traversal: "); preorder(root);

printf("\n");

printf("Postorder Traversal: "); postorder(root);

printf("\n");

return 0;

}

|  |  |  |
| --- | --- | --- |
| **Ex. No.: 11** | **Graph Traversal** | **Date: 24/5/24** |

**Write a C p r o g r a m t o c r e a t e a g r a p h a n d p e r f o r m a B r e a d t h F i r s t S e a r c h .**

**Algorithm:** #include <stdio.h> #include <stdlib.h>

struct node {

int vertex; struct node\* next;

};

struct adj\_list { struct node\* head;

};

struct graph {

int num\_vertices;

struct adj\_list\* adj\_lists; int\* visited;

};

struct node\* new\_node(int vertex) {

struct node\* new\_node = (struct node\*)malloc(sizeof(struct node)); new\_node->vertex = vertex;

new\_node->next = NULL; return new\_node;

}

struct graph\* create\_graph(int n) {

struct graph\* graph = (struct graph\*)malloc(sizeof(struct graph)); graph->num\_vertices = n;

graph->adj\_lists = (struct adj\_list\*)malloc(n \* sizeof(struct adj\_list)); graph->visited = (int\*)malloc(n \* sizeof(int));

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

graph->adj\_lists[i].head = NULL; graph->visited[i] = 0;

}

return graph;

}

void add\_edge(struct graph\* graph, int src, int dest) { struct node\* new\_node1 = new\_node(dest);

new\_node1->next = graph->adj\_lists[src].head; graph->adj\_lists[src].head = new\_node1;

struct node\* new\_node2 = new\_node(src);

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new\_node2->next = graph->adj\_lists[dest].head; graph->adj\_lists[dest].head = new\_node2;

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}

void bfs(struct graph\* graph, int v) { int queue[1000];

int front = -1; int rear = -1;

graph->visited[v] = 1; queue[++rear] = v; while (front != rear) {

int current\_vertex = queue[++front]; printf("%d ", current\_vertex);

struct node\* temp = graph->adj\_lists[current\_vertex].head; while (temp != NULL) {

int adj\_vertex = temp->vertex;

if (graph->visited[adj\_vertex] == 0) { graph->visited[adj\_vertex] = 1; queue[++rear] = adj\_vertex;

}

temp = temp->next;

}

}

}

int main() {

struct graph\* graph = create\_graph(6);

|  |  |  |
| --- | --- | --- |
| add\_edge(graph, | 0, | 1); |
| add\_edge(graph, | 0, | 2); |
| add\_edge(graph, | 1, | 3); |
| add\_edge(graph, | 1, | 4); |
| add\_edge(graph, | 2, | 4); |
| add\_edge(graph, | 3, | 4); |
| add\_edge(graph, | 3, | 5); |
| add\_edge(graph, | 4, | 5); |

printf("BFS traversal starting from vertex 0: "); bfs(graph, 0);

return 0;

}

|  |  |  |
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| **Ex. No.: 11** | **Graph Traversal** | **Date: 24/5/24** |

**Write a C p r o g r a m t o c r e a t e a g r a p h a n d p e r f o r m a D e p t h F i r s t S e a r c h .**

**Algorithm:** #include <stdio.h> #include <stdlib.h>

int vis[100];

struct Graph { int V;

int E; int\*\* Adj;

};

struct Graph\* adjMatrix() {

struct Graph\* G = (struct Graph\*)malloc(sizeof(struct Graph)); if (!G) {

printf("Memory Error\n"); return NULL;

}

G->V = 7;

G->E = 7;

G->Adj = (int\*\*)malloc((G->V) \* sizeof(int\*)); for (int k = 0; k < G->V; k++) {

G->Adj[k] = (int\*)malloc((G->V) \* sizeof(int));

}

for (int u = 0; u < G->V; u++) { for (int v = 0; v < G->V; v++) {

G->Adj[u][v] = 0;

}

}

G->Adj[0][1] = G->Adj[1][0] = 1;

G->Adj[0][2] = G->Adj[2][0] = 1;

G->Adj[1][3] = G->Adj[3][1] = 1;

G->Adj[1][4] = G->Adj[4][1] = 1;

G->Adj[1][5] = G->Adj[5][1] = 1;

G->Adj[1][6] = G->Adj[6][1] = 1;

G->Adj[6][2] = G->Adj[2][6] = 1;

return G;

}

void DFS(struct Graph\* G, int u) { vis[u] = 1;

printf("%d ", u);

for (int v = 0; v < G->V; v++) {

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if (!vis[v] && G->Adj[u][v]) { DFS(G, v);

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}

}

}

void DFStraversal(struct Graph\* G) { for (int i = 0; i < 100; i++) {

vis[i] = 0;

}

for (int i = 0; i < G->V; i++) { if (!vis[i]) {

DFS(G, i);

}

}

}

void main() {

struct Graph\* G; G = adjMatrix(); DFStraversal(G);

}

|  |  |  |
| --- | --- | --- |
| **Ex. No.: 12** | **Topological Sorting** | **Date: 24/5/24** |

**Write a C p r o g r a m t o c r e a t e a g r a p h a n d d i s p l a y t h e o r d e r i n g o f v e r t i c e s .**

**Algorithm:** #include <stdio.h> #include <malloc.h>

struct node {

int vertex; struct node\* next;

};

struct Graph {

int numVertices; struct node\*\* adjLists; int\* visited;

};

struct node\* createNode(int v) {

struct node\* newNode = (struct node\*)malloc(sizeof(struct node)); newNode->vertex = v;

newNode->next = NULL; return newNode;

}

struct Graph\* createGraph(int vertices) {

struct Graph\* graph = (struct Graph\*)malloc(sizeof(struct Graph)); graph->numVertices = vertices;

graph->adjLists = (struct node\*\*)malloc(vertices \* sizeof(struct node\*)); graph->visited = (int\*)malloc(vertices \* sizeof(int));

for (int i = 0; i < vertices; i++) { graph->adjLists[i] = NULL; graph->visited[i] = 0;

}

return graph;

}

void addEdge(struct Graph\* graph, int src, int dest) { struct node\* newNode = createNode(dest);

newNode->next = graph->adjLists[src]; graph->adjLists[src] = newNode;

}

void topologicalSortUtil(int v, struct Graph\* graph, int\* stack, int\* stackIndex) { graph->visited[v] = 1;

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struct node\* adjList = graph->adjLists[v]; struct node\* temp = adjList;

while (temp != NULL) {

int connectedVertex = temp->vertex;

if (!graph->visited[connectedVertex]) { topologicalSortUtil(connectedVertex, graph, stack, stackIndex);

}

temp = temp->next;

}

stack[(\*stackIndex)++] = v;

}

void topologicalSort(struct Graph\* graph) {

int\* stack = (int\*)malloc(graph->numVertices \* sizeof(int)); int stackIndex = 0;

for (int i = 0; i < graph->numVertices; i++) { if (graph->visited[i] == 0) {

topologicalSortUtil(i, graph, stack, &stackIndex);

}

}

for (int i = stackIndex - 1; i >= 0; i--) { printf("%d ", stack[i]);

}

free(stack);

}

int main() {

struct Graph\* graph = createGraph(6);

|  |  |  |
| --- | --- | --- |
| addEdge(graph, | 5, | 2); |
| addEdge(graph, | 5, | 0); |
| addEdge(graph, | 4, | 0); |
| addEdge(graph, | 4, | 1); |
| addEdge(graph, | 2, | 3); |
| addEdge(graph, | 3, | 1); |

printf("Topological Sort: "); topologicalSort(graph); printf("\n");

return 0;

}

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| **Ex. No.: 13** | **Graph Traversal** | **Date: 31/5/24** |

**Write a C p r o g r a m t o c r e a t e a g r a p h a n d f i n d a m i n i m u m s p a n n i n g t r e e u s i n g p r i m s a l g o r i t h m .**

**Algorithm:** #include <stdio.h> #include <limits.h>

#define MAX\_VERTICES 100

int minKey(int key[], int mstSet[], int vertices) { int min = INT\_MAX, minIndex;

for (int v = 0; v < vertices; v++) { if (!mstSet[v] && key[v] < min) {

min = key[v]; minIndex = v;

}

}

return minIndex;

}

void printMST(int parent[], int graph[MAX\_VERTICES][MAX\_VERTICES], int vertices) { printf("Edge \tWeight\n");

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

printf("%d - %d \t%d\n", parent[i], i, graph[i][parent[i]]);

}

}

void primMST(int graph[MAX\_VERTICES][MAX\_VERTICES], int vertices) { int parent[MAX\_VERTICES];

int key[MAX\_VERTICES]; int mstSet[MAX\_VERTICES];

for (int i = 0; i < vertices; i++) { key[i] = INT\_MAX;

mstSet[i] = 0;

}

key[0] = 0;

parent[0] = -1;

for (int count = 0; count < vertices - 1; count++) { int u = minKey(key, mstSet, vertices);

mstSet[u] = 1;

for (int v = 0; v < vertices; v++) {

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if (graph[u][v] && !mstSet[v] && graph[u][v] < key[v]) { parent[v] = u;

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key[v] = graph[u][v];

}

}

}

printMST(parent, graph, vertices);

}

int main() {

int vertices;

printf("Input the number of vertices: "); scanf("%d", &vertices);

if (vertices <= 0 || vertices > MAX\_VERTICES) { printf("Invalid number of vertices. Exiting...\n"); return 1;

}

int graph[MAX\_VERTICES][MAX\_VERTICES];

printf("Input the adjacency matrix for the graph:\n"); for (int i = 0; i < vertices; i++) {

for (int j = 0; j < vertices; j++) { scanf("%d", &graph[i][j]);

}

}

primMST(graph, vertices); return 0;

}

|  |  |  |
| --- | --- | --- |
| **Ex. No.: 14** | **Graph Traversal** | **Date: 31/5/24** |

**Write a C p r o g r a m t o c r e a t e a g r a p h a n d f i n d t h e s h o r t e s t p a t h u s i n g D i j i k s t r a ’ s A l g o r i t h m .**

**Algorithm:** #include <stdio.h> #include <limits.h>

#define MAX\_VERTICES 100

int minDistance(int dist[], int sptSet[], int vertices) { int min = INT\_MAX, minIndex;

for (int v = 0; v < vertices; v++) { if (!sptSet[v] && dist[v] < min) {

min = dist[v]; minIndex = v;

}

}

return minIndex;

}

void printSolution(int dist[], int vertices) { printf("Vertex \tDistance from Source\n"); for (int i = 0; i < vertices; i++) {

printf("%d \t%d\n", i, dist[i]);

}

}

void dijkstra(int graph[MAX\_VERTICES][MAX\_VERTICES], int src, int vertices) { int dist[MAX\_VERTICES];

int sptSet[MAX\_VERTICES];

for (int i = 0; i < vertices; i++) { dist[i] = INT\_MAX;

sptSet[i] = 0;

}

dist[src] = 0;

for (int count = 0; count < vertices - 1; count++) { int u = minDistance(dist, sptSet, vertices); sptSet[u] = 1;

for (int v = 0; v < vertices; v++) {

if (!sptSet[v] && graph[u][v] && dist[u] != INT\_MAX && dist[u] + graph[u][v] < dist[v]) {

dist[v] = dist[u] + graph[u][v];

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}

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}

}

printSolution(dist, vertices);

}

int main() {

int vertices;

printf("Input the number of vertices: "); scanf("%d", &vertices);

if (vertices <= 0 || vertices > MAX\_VERTICES) { printf("Invalid number of vertices. Exiting...\n"); return 1;

}

int graph[MAX\_VERTICES][MAX\_VERTICES];

printf("Input the adjacency matrix for the graph (use INT\_MAX for infinity):\n");

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

for (int j = 0; j < vertices; j++) { scanf("%d", &graph[i][j]);

}

}

int source;

printf("Input the source vertex: "); scanf("%d", &source);

if (source < 0 || source >= vertices) { printf("Invalid source vertex. Exiting...\n"); return 1;

}

dijkstra(graph, source, vertices); return 0;

}

|  |  |  |
| --- | --- | --- |
| **Ex. No.: 15** | **Sorting** | **Date: 31/5/24** |

**Write a C p r o g r a m t o t a k e n n u m b e r s a n d s o r t t h e n u m b e r s i n a s c e n d i n g o r d e r . T r y t o i m p l e m e n t t h e s a m e u s i n g f o l l o w i n g s o r t i n g t e c h n i q u e s .**

1. **Quick Sort**
2. **Merge Sort**

**Code :**

#include <stdio.h>

void swap(int\* a, int\* b) { int temp = \*a;

\*a = \*b;

\*b = temp;

}

int partition(int arr[], int low, int high) { int pivot = arr[low];

int i = low; int j = high; while (i < j) {

while (arr[i] <= pivot && i <= high - 1) { i++;

}

while (arr[j] > pivot && j >= low + 1) { j--;

}

if (i < j) {

swap(&arr[i], &arr[j]);

}

}

swap(&arr[low], &arr[j]); return j;

}

void quickSort(int arr[], int low, int high) { if (low < high) {

int partitionIndex = partition(arr, low, high); quickSort(arr, low, partitionIndex - 1); quickSort(arr, partitionIndex + 1, high);

}

}

int main() {

int arr[] = { 19, 17, 15, 12, 16, 18, 4, 11, 13 };

int n = sizeof(arr) / sizeof(arr[0]);

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printf("Original array: "); for (int i = 0; i < n; i++) {

printf("%d ", arr[i]);

}

quickSort(arr, 0, n - 1);

printf("\nSorted array: "); for (int i = 0; i < n; i++) {

printf("%d ", arr[i]);

}

return 0;

}

# Merge Sort

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

void merge(int arr[], int l, int m, int r) { int i, j, k;

int n1 = m - l + 1; int n2 = r - m;

int L[n1], R[n2];

for (i = 0; i < n1; i++) L[i] = arr[l + i];

for (j = 0; j < n2; j++) R[j] = arr[m + 1 + j];

i = 0;

j = 0;

k = l;

while (i < n1 && j < n2) { if (L[i] <= R[j]) {

arr[k] = L[i]; i++;

} else {

arr[k] = R[j]; j++;

} k++;

}

while (i < n1) { arr[k] = L[i];

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i++; k++;

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}

while (j < n2) { arr[k] = R[j]; j++;

k++;

}

}

void mergeSort(int arr[], int l, int r) { if (l < r) {

int m = l + (r - l) / 2; mergeSort(arr, l, m); mergeSort(arr, m + 1, r); merge(arr, l, m, r);

}

}

void printArray(int A[], int size) { int i;

for (i = 0; i < size; i++) printf("%d ", A[i]);

printf("\n");

}

int main() {

int arr[] = { 12, 11, 13, 5, 6, 7 };

int arr\_size = sizeof(arr) / sizeof(arr[0]); printf("Given array is \n"); printArray(arr, arr\_size);

mergeSort(arr, 0, arr\_size - 1); printf("\nSorted array is \n"); printArray(arr, arr\_size); return 0;

}

|  |  |  |
| --- | --- | --- |
| **Ex. No.: 16** | **Hashing** | **Date: 31/5/24** |

**Write a C p r o g r a m t o c r e a t e a h a s h t a b l e a n d p e r f o r m c o l l i s i o n r e s o l u t i o n u s i n g t h e f o l l o w i n g t e c h n i q u e s .**

* 1. **O p e n a d d r e s s i n g**
  2. **C l o s e d A d d r e s s i n g**
  3. **R e h a s h i n g Algorithm:**

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

typedef struct HashTable { int size;

int count; // Number of elements in the table int\* keys;

int\* values;

bool\* isOccupied; // Indicates if a slot is occupied

} HashTable;

HashTable\* createTable(int size) {

HashTable\* newTable = (HashTable\*)malloc(sizeof(HashTable)); newTable->size = size;

newTable->count = 0;

newTable->keys = (int\*)malloc(sizeof(int) \* size); newTable->values = (int\*)malloc(sizeof(int) \* size); newTable->isOccupied = (bool\*)malloc(sizeof(bool) \* size); for (int i = 0; i < size; i++) {

newTable->isOccupied[i] = false;

}

return newTable;

}

int hashFunction(int key, int size) { return key % size;

}

void rehash(HashTable\* hashTable);

void insert(HashTable\* hashTable, int key, int value) {

if ((float)hashTable->count / hashTable->size >= 0.75) { rehash(hashTable);

}

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int hashIndex = hashFunction(key, hashTable->size); int originalIndex = hashIndex;

int i = 1;

while (hashTable->isOccupied[hashIndex]) { if (hashTable->keys[hashIndex] == key) {

// If the key already exists, update the value hashTable->values[hashIndex] = value;

return;

}

// Linear probing

hashIndex = (originalIndex + i) % hashTable->size; i++;

}

hashTable->keys[hashIndex] = key; hashTable->values[hashIndex] = value; hashTable->isOccupied[hashIndex] = true; hashTable->count++;

}

void rehash(HashTable\* hashTable) { int oldSize = hashTable->size; int\* oldKeys = hashTable->keys;

int\* oldValues = hashTable->values;

bool\* oldIsOccupied = hashTable->isOccupied;

int newSize = oldSize \* 2;

hashTable->keys = (int\*)malloc(sizeof(int) \* newSize); hashTable->values = (int\*)malloc(sizeof(int) \* newSize); hashTable->isOccupied = (bool\*)malloc(sizeof(bool) \* newSize); hashTable->size = newSize;

hashTable->count = 0;

for (int i = 0; i < newSize; i++) { hashTable->isOccupied[i] = false;

}

for (int i = 0; i < oldSize; i++) { if (oldIsOccupied[i]) {

insert(hashTable, oldKeys[i], oldValues[i]);

}

}

free(oldKeys); free(oldValues); free(oldIsOccupied);

}

int search(HashTable\* hashTable, int key) {

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int hashIndex = hashFunction(key, hashTable->size); int originalIndex = hashIndex;

int i = 1;

while (hashTable->isOccupied[hashIndex]) { if (hashTable->keys[hashIndex] == key) {

return hashTable->values[hashIndex];

}

// Linear probing

hashIndex = (originalIndex + i) % hashTable->size; i++;

if (hashIndex == originalIndex) {

break; // We have circled back to the original index

}

}

return -1; // Key not found

}

void delete(HashTable\* hashTable, int key) {

int hashIndex = hashFunction(key, hashTable->size); int originalIndex = hashIndex;

int i = 1;

while (hashTable->isOccupied[hashIndex]) { if (hashTable->keys[hashIndex] == key) {

hashTable->isOccupied[hashIndex] = false; hashTable->count--;

return;

}

// Linear probing

hashIndex = (originalIndex + i) % hashTable->size; i++;

if (hashIndex == originalIndex) {

break; // We have circled back to the original index

}

}

}

void freeTable(HashTable\* hashTable) { free(hashTable->keys); free(hashTable->values); free(hashTable->isOccupied); free(hashTable);

}

int main() {

HashTable\* hashTable = createTable(5); insert(hashTable, 1, 10);

insert(hashTable, 2, 20);

insert(hashTable, 3, 30);

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insert(hashTable, 4, 40);

insert(hashTable, 5, 50);

insert(hashTable, 6, 60); // This should trigger rehashing printf("Value for key 1: %d\n", search(hashTable, 1)); printf("Value for key 2: %d\n", search(hashTable, 2)); printf("Value for key 3: %d\n", search(hashTable, 3)); printf("Value for key 4: %d\n", search(hashTable, 4)); printf("Value for key 5: %d\n", search(hashTable, 5)); printf("Value for key 6: %d\n", search(hashTable, 6)); delete(hashTable, 3);

printf("Value for key 3 after deletion: %d\n", search(hashTable, 3)); freeTable(hashTable);

return 0;

}

2.CLOSED ADDRESSING

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

typedef struct Node { int key;

int value;

struct Node\* next;

} Node;

typedef struct HashTable { int size;

Node\*\* table;

} HashTable;

Node\* createNode(int key, int value) {

Node\* newNode = (Node\*)malloc(sizeof(Node)); newNode->key = key;

newNode->value = value; newNode->next = NULL; return newNode;

}

HashTable\* createTable(int size) {

HashTable\* newTable = (HashTable\*)malloc(sizeof(HashTable)); newTable->size = size;

newTable->table = (Node\*\*)malloc(sizeof(Node\*) \* size); for (int i = 0; i < size; i++) {

newTable->table[i] = NULL;

}

return newTable;

}

.

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int hashFunction(int key, int size) { return key % size;

}

void insert(HashTable\* hashTable, int key, int value) { int hashIndex = hashFunction(key, hashTable->size); Node\* newNode = createNode(key, value);

newNode->next = hashTable->table[hashIndex]; hashTable->table[hashIndex] = newNode;

}

int search(HashTable\* hashTable, int key) {

int hashIndex = hashFunction(key, hashTable->size); Node\* current = hashTable->table[hashIndex];

while (current != NULL) {

if (current->key == key) { return current->value;

}

current = current->next;

}

return -1;

}

void delete(HashTable\* hashTable, int key) {

int hashIndex = hashFunction(key, hashTable->size); Node\* current = hashTable->table[hashIndex];

Node\* prev = NULL;

while (current != NULL && current->key != key) { prev = current;

current = current->next;

}

if (current == NULL) { return;

}

if (prev == NULL) {

hashTable->table[hashIndex] = current->next;

} else {

prev->next = current->next;

}

free(current);

}

void freeTable(HashTable\* hashTable) {

for (int i = 0; i < hashTable->size; i++) { Node\* current = hashTable->table[i]; while (current != NULL) {

Node\* temp = current; current = current->next; free(temp);

.

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}

}

free(hashTable->table); free(hashTable);

}

int main() {

HashTable\* hashTable = createTable(10); insert(hashTable, 1, 10);

insert(hashTable, 2, 20);

insert(hashTable, 12, 30);

printf("Value for key 1: %d\n", search(hashTable, 1)); printf("Value for key 2: %d\n", search(hashTable, 2)); printf("Value for key 12: %d\n", search(hashTable, 12));

printf("Value for key 3: %d\n", search(hashTable, 3)); // Key not present delete(hashTable, 2);

printf("Value for key 2 after deletion: %d\n", search(hashTable, 2)); freeTable(hashTable);

return 0;

}

# C) REHASHING

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

typedef struct Node { int key;

int value;

struct Node\* next;

} Node;

typedef struct HashTable { int size;

int count; // Number of elements in the table Node\*\* table;

} HashTable;

Node\* createNode(int key, int value) {

Node\* newNode = (Node\*)malloc(sizeof(Node)); newNode->key = key;

newNode->value = value; newNode->next = NULL; return newNode;

}

HashTable\* createTable(int size) {

HashTable\* newTable = (HashTable\*)malloc(sizeof(HashTable)); newTable->size = size;

.

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newTable->count = 0;

newTable->table = (Node\*\*)malloc(sizeof(Node\*) \* size); for (int i = 0; i < size; i++) {

newTable->table[i] = NULL;

}

return newTable;

}

int hashFunction(int key, int size) { return key % size;

}

void insert(HashTable\* hashTable, int key, int value); void rehash(HashTable\* hashTable) {

int oldSize = hashTable->size; Node\*\* oldTable = hashTable->table; int newSize = oldSize \* 2;

hashTable->table = (Node\*\*)malloc(sizeof(Node\*) \* newSize); hashTable->size = newSize;

hashTable->count = 0;

for (int i = 0; i < newSize; i++) { hashTable->table[i] = NULL;

}

for (int i = 0; i < oldSize; i++) { Node\* current = oldTable[i]; while (current != NULL) {

insert(hashTable, current->key, current->value); Node\* temp = current;

current = current->next; free(temp);

}

}

free(oldTable);

}

void insert(HashTable\* hashTable, int key, int value) {

if ((float)hashTable->count / hashTable->size >= 0.75) { rehash(hashTable);

}

int hashIndex = hashFunction(key, hashTable->size); Node\* newNode = createNode(key, value);

newNode->next = hashTable->table[hashIndex]; hashTable->table[hashIndex] = newNode; hashTable->count++;

}

int search(HashTable\* hashTable, int key) {

int hashIndex = hashFunction(key, hashTable->size); Node\* current = hashTable->table[hashIndex];

while (current != NULL) {

.

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if (current->key == key) { return current->value;

}

current = current->next;

}

return -1;

}

void delete(HashTable\* hashTable, int key) {

int hashIndex = hashFunction(key, hashTable->size); Node\* current = hashTable->table[hashIndex];

Node\* prev = NULL;

while (current != NULL && current->key != key) { prev = current;

current = current->next;

}

if (current == NULL) { return;

}

if (prev == NULL) {

hashTable->table[hashIndex] = current->next;

} else {

prev->next = current->next;

}

free(current); hashTable->count--;

}

void freeTable(HashTable\* hashTable) {

for (int i = 0; i < hashTable->size; i++) { Node\* current = hashTable->table[i]; while (current != NULL) {

Node\* temp = current; current = current->next; free(temp);

}

}

free(hashTable->table); free(hashTable);

}

int main() {

HashTable\* hashTable = createTable(5); insert(hashTable, 1, 10);

insert(hashTable, 2, 20);

insert(hashTable, 3, 30);

insert(hashTable, 4, 40);

insert(hashTable, 5, 50);

insert(hashTable, 6, 60); // This should trigger rehashing printf("Value for key 1: %d\n", search(hashTable, 1));

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printf("Value for key 2: %d\n", search(hashTable, 2)); printf("Value for key 3: %d\n", search(hashTable, 3)); printf("Value for key 4: %d\n", search(hashTable, 4)); printf("Value for key 5: %d\n", search(hashTable, 5)); printf("Value for key 6: %d\n", search(hashTable, 6)); delete(hashTable, 3);

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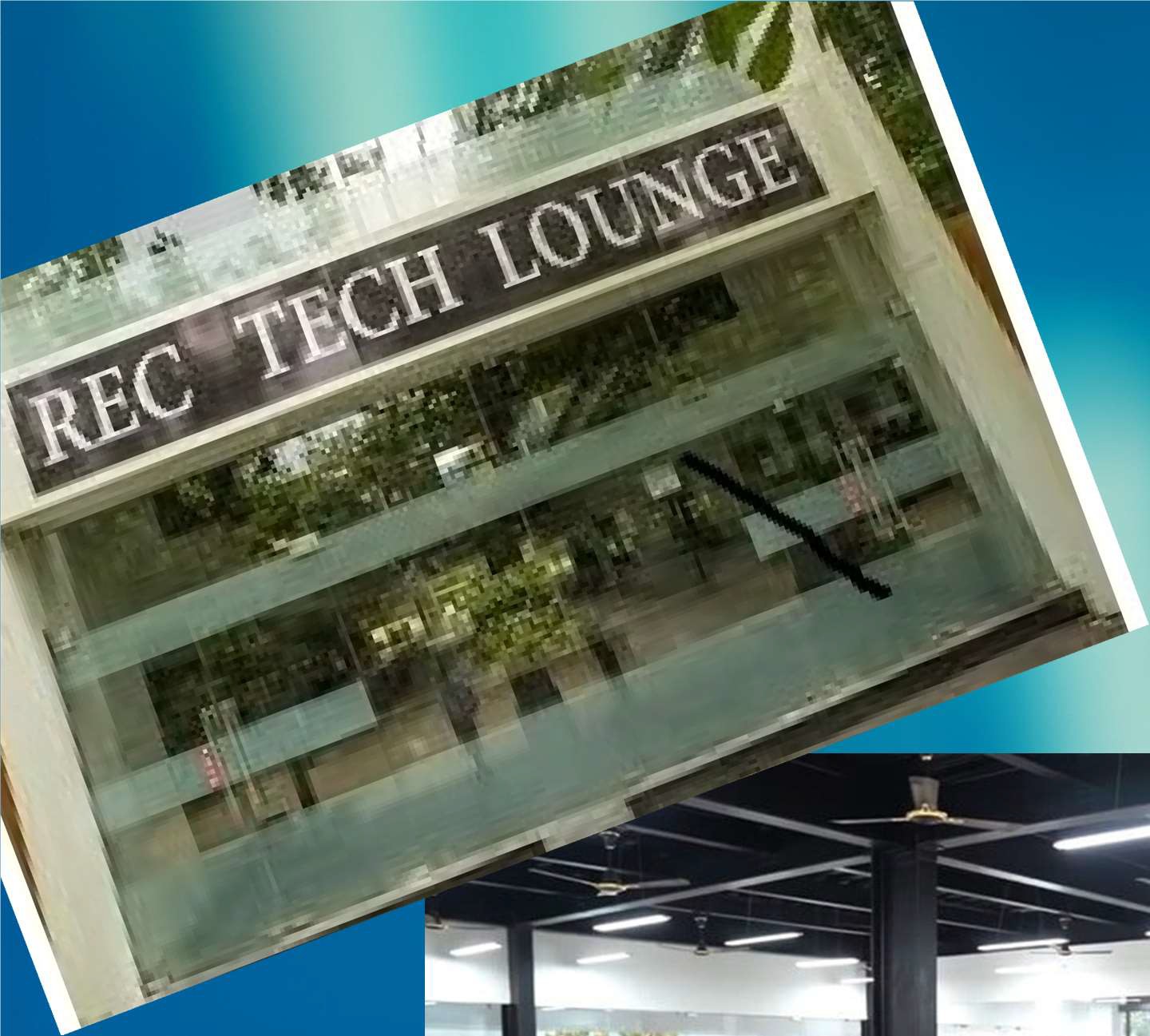
printf("Value for key 3 after deletion: %d\n", search(hashTable, 3)); freeTable(hashTable);

return 0;

}

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