

DESIGN & ANALYSIS OF ALGORITHM LAB

(ACS551)

LIST OF EXPERIMENTS

1. Implementation of Quick Sort and Merge Sort.
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7. Implementation of Minimum Spanning Tree Algorithm.
8. Implementation of Single-pair shortest path Algorithm.
9. Implementation of All-pair shortest path Algorithm.
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1.Implementation of Quick Sort and Merge Sort.

// Quick sort in C

```
#include <stdio.h>

// function to swap elements
void swap(int *a, int *b) {
    int t = *a;
    *a = *b;
    *b = t;
}

// function to find the partition position
int partition(int array[], int low, int high) {
    // select the rightmost element as pivot
    int pivot = array[high];

    // pointer for greater element
    int i = (low - 1);

    // traverse each element of the array
    // compare them with the pivot
    for (int j = low; j < high; j++) {
        if (array[j] <= pivot) {
            // if element smaller than pivot is found
            // swap it with the greater element pointed by i
            i++;
            // swap element at i with element at j
            swap(&array[i], &array[j]);
        }
    }

    // swap the pivot element with the greater element at i
    swap(&array[i + 1], &array[high]);

    // return the partition point
    return (i + 1);
}
```

```

}

void quickSort(int array[], int low, int high) {
    if (low < high) {
        // find the pivot element such that
        // elements smaller than pivot are on left of pivot
        // elements greater than pivot are on right of pivot

        int pi = partition(array, low, high);

        // recursive call on the left of pivot
        quickSort(array, low, pi - 1);

        // recursive call on the right of pivot
        quickSort(array, pi + 1, high);
    }
}

// function to print array elements
void printArray(int array[], int size) {
    for (int i = 0; i < size; ++i) {
        printf("%d ", array[i]);
    }

    printf("\n");
}

// main function
int main() {
    int data[] = {8, 7, 2, 1, 0, 9, 6};

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

    printf("Unsorted Array\n");

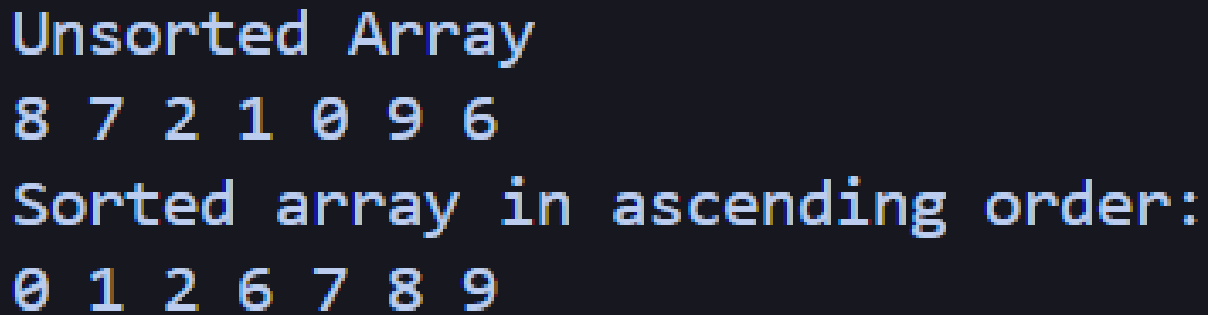
    printArray(data, n);

    // perform quicksort on data
    quickSort(data, 0, n - 1);

```

```
printf("Sorted array in ascending order: \n");  
printArray(data, n);  
}
```

OUTPUT:



```
Unsorted Array  
8 7 2 1 0 9 6  
Sorted array in ascending order:  
0 1 2 6 7 8 9
```

// Merge sort in C

```
#include <stdio.h>  
  
// Merge two subarrays L and M into arr  
void merge(int arr[], int p, int q, int r) {  
    // Create L ← A[p..q] and M ← A[q+1..r]  
    int n1 = q - p + 1;  
    int n2 = r - q;  
    int L[n1], M[n2];  
    for (int i = 0; i < n1; i++)  
        L[i] = arr[p + i];  
    for (int j = 0; j < n2; j++)  
        M[j] = arr[q + 1 + j];  
    // Maintain current index of sub-arrays and main array  
    int i, j, k;  
    i = 0;  
    j = 0;  
    k = p;
```

```
// Until we reach either end of either L or M, pick larger among  
// elements L and M and place them in the correct position at A[p..r]
```

```
while (i < n1 && j < n2) {  
    if (L[i] <= M[j]) {  
        arr[k] = L[i];  
        i++;  
    } else {  
        arr[k] = M[j];  
  
        j++;  
    }  
    k++;  
}
```

```
// When we run out of elements in either L or M,  
// pick up the remaining elements and put in A[p..r]
```

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

```
while (j < n2) {  
    arr[k] = M[j];  
    j++;  
    k++;  
}
```

```
}
```

```
// Divide the array into two subarrays, sort them and merge them
```

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

```
    if (l < r) {
```

```
        // m is the point where the array is divided into two subarrays
```

```
        int m = l + (r - l) / 2;
```

```
        mergeSort(arr, l, m);
```

```

mergeSort(arr, m + 1, r);

// Merge the sorted subarrays
merge(arr, l, m, r);
}
}

// Print the array
void printArray(int arr[], int size) {
    for (int i = 0; i < size; i++)
        printf("%d ", arr[i]);
    printf("\n");
}

// Driver program
int main() {
    int arr[] = {6, 5, 12, 10, 9, 1};
    int size = sizeof(arr) / sizeof(arr[0]);

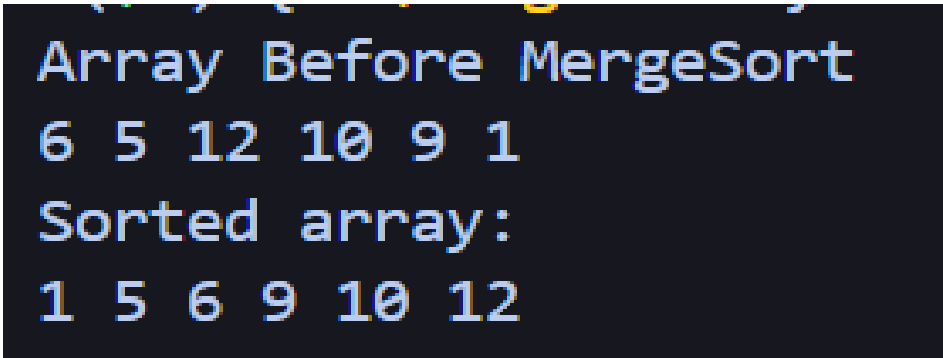
    printf("Array Before\nMergeSort\n");

    printArray(arr, size);

    mergeSort(arr, 0, size - 1);
    printf("Sorted array: \n");
    printArray(arr, size);
}

```

OUTPUT:



```

Array Before MergeSort
6 5 12 10 9 1
Sorted array:
1 5 6 9 10 12

```

2. Implementation of Linear-time Sorting Algorithms.

// Counting sort: an example of Linear-Time Sorting Algorithm.

```
#include <stdio.h>

void countingSort(int array[], int size) {
    int output[10];

    // Find the largest element of the array
    int max = array[0];
    for (int i = 1; i < size; i++) {
        if (array[i] > max)
            max = array[i];
    }

    // The size of count must be at least (max+1) but
    // we cannot declare it as int count(max+1) in C as
    // it does not support dynamic memory allocation.
    // So, its size is provided statically.
    int count[10];

    // Initialize count array with all zeros.
    for (int i = 0; i <= max; ++i) {
        count[i] = 0;
    }

    // Store the count of each element
    for (int i = 0; i < size; i++) {

        count[array[i]]++;
    }

    // Store the cumulative count of each array
    for (int i = 1; i <= max; i++) {
        count[i] += count[i - 1];
    }
}
```

```

// Find the index of each element of the original array in count array, and
// place the elements in output array
for (int i = size - 1; i >= 0; i--) {
    output[count[array[i]] - 1] = array[i];
    count[array[i]]--;
}

// Copy the sorted elements into original array
for (int i = 0; i < size; i++) {
    array[i] = output[i];
}

// Function to print an array
void printArray(int array[], int size) { for (int i = 0; i < size; ++i) { printf("%d ", array[i]);
}
printf("\n");
}

int main() {
    int array[] = {4, 2, 2, 8, 3, 3, 1};
    int n = sizeof(array) / sizeof(array[0]);
    countingSort(array, n);
    printf("Sorted Array:");
    printArray(array, n);
}

```

OUTPUT:

```
Sorted array:1 2 2 3 3 4 8
```

3. Implementation of Red-Black Tree operations.

//Red Black Tree Operations

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



```

#include <stdlib.h>
enum nodeColor {
    RED,
    BLACK
};

struct rbNode {
    int data, color;
    struct rbNode *link[2];
};

struct rbNode *root = NULL;

// Create a red-black tree
struct rbNode *createNode(int data) {
    struct rbNode *newnode;
    newnode = (struct rbNode *)malloc(sizeof(struct rbNode));
    newnode->data = data;
    newnode->color = RED;
    newnode->link[0] = newnode->link[1] = NULL;
    return newnode;
}

// Insert an node
void insertion(int data) {
    struct rbNode *stack[98], *ptr, *newnode, *xPtr, *yPtr;
    int dir[98], ht = 0, index;
    ptr = root;
    if (!root) {
        root = createNode(data);
        return;
    }

    stack[ht] = root;
    dir[ht++] = 0;
    while (ptr != NULL) {
        if (ptr->data == data) {
            printf("Duplicates Not Allowed!!\n");
            return;
        }

        index = (data - ptr->data) > 0 ? 1 : 0;
        stack[ht] = ptr;
        ptr = ptr->link[index];
        dir[ht++] = index;
    }

    stack[ht - 1]->link[index] = newnode = createNode(data);
    while ((ht >= 3) && (stack[ht - 1]->color == RED)) {
        if (dir[ht - 2] == 0) {
            yPtr = stack[ht - 2]->link[1];
            if (yPtr != NULL && yPtr->color == RED) {

```

```

stack[ht - 2]->color = RED;
stack[ht - 1]->color = yPtr->color = BLACK;
ht = ht - 2;
} else {
    if (dir[ht - 1] == 0) {
        yPtr = stack[ht - 1];
    } else {
        xPtr = stack[ht - 1];
        yPtr = xPtr->link[1];
        xPtr->link[1] = yPtr->link[0];
        yPtr->link[0] = xPtr;
        stack[ht - 2]->link[0] = yPtr;
    }

    xPtr = stack[ht - 2];
    xPtr->color = RED;
    yPtr->color = BLACK;
    xPtr->link[0] = yPtr->link[1];
    yPtr->link[1] = xPtr;
    if (xPtr == root) {
        root = yPtr;
    } else {
        stack[ht - 3]->link[dir[ht - 3]] = yPtr;
    }

    break;
}

} else {
    yPtr = stack[ht - 2]->link[0];
    if ((yPtr != NULL) && (yPtr->color == RED)) {
        stack[ht - 2]->color = RED;
        stack[ht - 1]->color = yPtr->color = BLACK;
        ht = ht - 2;
    } else {
        if (dir[ht - 1] == 1) {
            yPtr = stack[ht - 1];
        } else {
            xPtr = stack[ht - 1];
            yPtr = xPtr->link[0];
            xPtr->link[0] = yPtr->link[1];
            yPtr->link[1] = xPtr;
            stack[ht - 2]->link[1] = yPtr;
        }

        xPtr = stack[ht - 2];
        yPtr->color = BLACK;
        xPtr->color = RED;
        xPtr->link[1] = yPtr->link[0];
        yPtr->link[0] = xPtr;
        if (xPtr == root) {
            root = yPtr;
        } else {
            stack[ht - 3]->link[dir[ht - 3]] = yPtr;

```

```

    }
    break;
}

}

}

root->color = BLACK;
}

```

// Delete a node

```

void deletion(int data) {
    struct rbNode *stack[98], *ptr, *xPtr, *yPtr;
    struct rbNode *pPtr, *qPtr, *rPtr;
    int dir[98], ht = 0, diff, i;
    enum nodeColor color;
    if (!root) {
        printf("Tree not available\n");
        return;
    }

    ptr = root;
    while (ptr != NULL) {
        if ((data - ptr->data) == 0)
            break;
        diff = (data - ptr->data) > 0 ? 1 : 0;
        stack[ht] = ptr;
        dir[ht++] = diff;
        ptr = ptr->link[diff];
    }

    if (ptr->link[1] == NULL) {
        if ((ptr == root) && (ptr->link[0] == NULL)) {
            free(ptr);
            root = NULL;
        } else if (ptr == root) {
            root = ptr->link[0];
            free(ptr);
        } else {
            stack[ht - 1]->link[dir[ht - 1]] = ptr->link[0];
        }
    } else {
        xPtr = ptr->link[1];
        if (xPtr->link[0] == NULL) {
            xPtr->link[0] = ptr->link[0];
            color = xPtr->color;
            xPtr->color = ptr->color;
            ptr->color = color;

```

```

    if (ptr == root) {
        root = xPtr;
    } else {
        stack[ht - 1]->link[dir[ht - 1]] = xPtr;
    }

    dir[ht] = 1;
    stack[ht++] = xPtr;
} else {
    i = ht++;
    while (1) {
dir[ht] = 0; stack[ht++] = xPtr;

yPtr = xPtr->link[0];

        if (!yPtr->link[0])
            break;
        xPtr = yPtr;
    }

    dir[i] = 1;
    stack[i] = yPtr;
    if (i > 0)
        stack[i - 1]->link[dir[i - 1]] = yPtr;

    yPtr->link[0] = ptr->link[0];

    xPtr->link[0] = yPtr->link[1];
    yPtr->link[1] = ptr->link[1];

    if (ptr == root) {
        root = yPtr;
    }

    color = yPtr->color;
    yPtr->color = ptr->color;
    ptr->color = color;
}
}

if (ht < 1)
    return;

if (ptr->color == BLACK) {
    while (1) {
        pPtr = stack[ht - 1]->link[dir[ht - 1]];
        if (pPtr && pPtr->color == RED) {
            pPtr->color = BLACK;
            break;
        }
    }
}

```

```

if (ht < 2)
    break;

if (dir[ht - 2] == 0) {
    rPtr = stack[ht - 1]->link[1];

    if (!rPtr)
        break;

    if (rPtr->color == RED) {
        stack[ht - 1]->color = RED;
        rPtr->color = BLACK;
        stack[ht - 1]->link[1] = rPtr->link[0];
        rPtr->link[0] = stack[ht - 1];

        if (stack[ht - 1] == root) {
            root = rPtr;
        } else {
            stack[ht - 2]->link[dir[ht - 2]] = rPtr;
        }

        dir[ht] = 0;
        stack[ht] = stack[ht - 1];
        stack[ht - 1] = rPtr;
        ht++;

        rPtr = stack[ht - 1]->link[1];
    }

    if ((!rPtr->link[0] || rPtr->link[0]->color == BLACK) &&
        (!rPtr->link[1] || rPtr->link[1]->color == BLACK)) {
        rPtr->color = RED;
    } else {
        if (!rPtr->link[1] || rPtr->link[1]->color == BLACK) {
            qPtr = rPtr->link[0];
            rPtr->color = RED;
            qPtr->color = BLACK;
            rPtr->link[0] = qPtr->link[1];
            qPtr->link[1] = rPtr;
            rPtr = stack[ht - 1]->link[1] = qPtr;
        }

        rPtr->color = stack[ht - 1]->color;
        stack[ht - 1]->color = BLACK;
        rPtr->link[1]->color = BLACK;
        stack[ht - 1]->link[1] = rPtr->link[0];
        rPtr->link[0] = stack[ht - 1];
        if (stack[ht - 1] == root) {
            root = rPtr;
        } else {
            stack[ht - 2]->link[dir[ht - 2]] = rPtr;
        }
    }
}

```

```

    break;
}

} else {
    rPtr = stack[ht - 1]->link[0];
    if (!rPtr)
        break;

    if (rPtr->color == RED) {
        stack[ht - 1]->color = RED;
        rPtr->color = BLACK;
        stack[ht - 1]->link[0] = rPtr->link[1];
        rPtr->link[1] = stack[ht - 1];

        if (stack[ht - 1] == root) {
            root = rPtr;
        } else {
            stack[ht - 2]->link[dir[ht - 2]] = rPtr;
        }

        dir[ht] = 1;
        stack[ht] = stack[ht - 1];
        stack[ht - 1] = rPtr;
        ht++;

        rPtr = stack[ht - 1]->link[0];
    }

    if ((!rPtr->link[0] || rPtr->link[0]->color == BLACK) &&
        (!rPtr->link[1] || rPtr->link[1]->color == BLACK)) {
        rPtr->color = RED;
    } else {
        if (!rPtr->link[0] || rPtr->link[0]->color == BLACK) {
            qPtr = rPtr->link[1];
            rPtr->color = RED;
            qPtr->color = BLACK;
            rPtr->link[1] = qPtr->link[0];
            qPtr->link[0] = rPtr;
            rPtr = stack[ht - 1]->link[0] = qPtr;
        }

        rPtr->color = stack[ht - 1]->color;
        stack[ht - 1]->color = BLACK;
        rPtr->link[0]->color = BLACK;
        stack[ht - 1]->link[0] = rPtr->link[1];
        rPtr->link[1] = stack[ht - 1];
        if (stack[ht - 1] == root) {
            root = rPtr;
        } else {
            stack[ht - 2]->link[dir[ht - 2]] = rPtr;
        }

        break;
    }
}

```

```

    }

    ht--;
}

}

}

```

// Print the inorder traversal of the tree

```

void inorderTraversal(struct rbNode *node) {
    if (node) {
        inorderTraversal(node->link[0]);
        printf("%d ", node->data);
        inorderTraversal(node->link[1]);
    }

    return;
}

```

// Driver code

```

int main() {
    int ch, data;
    while (1) {
        printf("1. Insertion\t2. Deletion\n");
        printf("3. Traverse\t4. Exit");
        printf("\nEnter your choice:");
        scanf("%d", &ch);
        switch (ch) {
            case 1:
                printf("Enter the element to insert:");
                scanf("%d", &data);
                insertion(data);
                break;
            case 2:
                printf("Enter the element to delete:");
                scanf("%d", &data);
                deletion(data);
                break;
            case 3:
                inorderTraversal(root);
                printf("\n");
                break;
            case 4:
                exit(0);
            default:
                printf("Not available\n");
                break;
        }

        printf("\n");
    }
}

```

```
}  
return 0;  
}
```

OUTPUT

```
1. Insertion    2. Deletion  
3. Traverse     4. Exit  
Enter your choice:1  
Enter the element to insert:78
```

```
1. Insertion    2. Deletion  
3. Traverse     4. Exit  
Enter your choice:1  
Enter the element to insert:90
```

```
1. Insertion    2. Deletion  
3. Traverse     4. Exit  
Enter your choice:1  
Enter the element to insert:45
```

```
3. Traverse     4. Exit  
Enter your choice:1  
Enter the element to insert:80
```

```
1. Insertion    2. Deletion  
3. Traverse     4. Exit  
Enter your choice:1  
Enter the element to insert:08
```

```
1. Insertion    2. Deletion  
3. Traverse     4. Exit  
Enter your choice:3
```

```
Enter your choice:3  
8 45 78 80 90
```

```
1. Insertion    2. Deletion  
3. Traverse     4. Exit  
Enter your choice:2  
Enter the element to delete:90
```

```
1. Insertion    2. Deletion  
3. Traverse     4. Exit  
Enter your choice:3  
8 45 78 80
```

```
1. Insertion    2. Deletion  
3. Traverse     4. Exit  
Enter your choice:4  
PS C:\Users\10582\Desktop\KMCLU_ACADEMIC\5
```


4. Implementation of Binomial Heap operations.

Binomial Heap Operation

```
// BinomialHeap
#include<stdio.h>
#include<malloc.h>
struct node {
    int n;
    int degree;
    struct node* parent;
    struct node* child;
    struct node* sibling;
};
struct node* MAKE_bin_HEAP();
int bin_LINK(struct node*, struct node*);
struct node* CREATE_NODE(int);
struct node* bin_HEAP_UNION(struct node*, struct node*);
struct node* bin_HEAP_INSERT(struct node*, struct node*);
struct node* bin_HEAP_MERGE(struct node*, struct node*);
struct node* bin_HEAP_EXTRACT_MIN(struct node*);
int REVERT_LIST(struct node*);
int DISPLAY(struct node*);
struct node* FIND_NODE(struct node*, int);
int bin_HEAP_DECREASE_KEY(struct node*, int, int);
int bin_HEAP_DELETE(struct node*, int);
int count = 1;
struct node* MAKE_bin_HEAP() {
    struct node* np;
    np = NULL;
    return np;
}
struct node * H = NULL;
struct node *Hr = NULL;
int bin_LINK(struct node* y, struct node* z) {
    y->parent = z;
    y->sibling = z->child;
    z->child = y;
    z->degree = z->degree + 1;
}
struct node* CREATE_NODE(int k) {
    struct node* p;
    //new node;
    p = (struct node*) malloc(sizeof(struct node));
    p->n = k;
    return p;
}
struct node* bin_HEAP_UNION(struct node* H1, struct node* H2) {
```

```

struct node* prev_x;
struct node* next_x;
struct node* x;
struct node* H = MAKE_bin_HEAP();
H = bin_HEAP_MERGE(H1, H2);
if (H == NULL)
return H;
prev_x = NULL;
x = H;
next_x = x->sibling;
while (next_x != NULL) {
if ((x->degree != next_x->degree) || ((next_x->sibling != NULL)
&& (next_x->sibling->degree == x->degree)) {
prev_x = x;
x = next_x;
} else {
if (x->n <= next_x->n) {
x->sibling = next_x->sibling;
bin_LINK(next_x, x);
} else {
if (prev_x == NULL)
H = next_x;
else
prev_x->sibling = next_x;
bin_LINK(x, next_x);
x = next_x;
}
}
next_x = x->sibling;
}
return H;
}

struct node* bin_HEAP_INSERT(struct node* H, struct node* x) {
struct node* H1 = MAKE_bin_HEAP();
x->parent = NULL;
x->child = NULL;
x->sibling = NULL;
x->degree = 0;
H1 = x;
H = bin_HEAP_UNION(H, H1);
return H;
}

struct node* bin_HEAP_MERGE(struct node* H1, struct node* H2) {
struct node* H = MAKE_bin_HEAP();
struct node* y;
struct node* z;
struct node* a;
struct node* b;

```

```

y = H1;
z = H2;
if (y != NULL) {
if (z != NULL && y->degree <= z->degree)
H = y;
else if (z != NULL && y->degree > z->degree)
/* need some modifications here;the first and the else conditions can be merged together!!!!
*/
H = z;
else
H = y;
} else
H = z;
while (y != NULL && z != NULL) {
if (y->degree < z->degree) {
y = y->sibling;
} else if (y->degree == z->degree) {
a = y->sibling;
y->sibling = z;
y = a;
} else {
b = z->sibling;
z->sibling = y;
z = b;
}
}
return H;
}
int DISPLAY(struct node* H) {
struct node* p;
if (H == NULL) {
printf("\nHEAP EMPTY");
return 0;
}
printf("\nTHE ROOT NODES ARE:-\n");
p = H;
while (p != NULL) {
printf("%d", p->n);
if (p->sibling != NULL)
printf("-->");
p = p->sibling;
}
printf("\n");
}
struct node* bin_HEAP_EXTRACT_MIN(struct node* H1) {
int min;
struct node* t = NULL;
struct node* x = H1;

```

```

struct node *Hr;
struct node* p;
Hr = NULL;
if (x == NULL) {
printf("\nNOTHING TO EXTRACT");
return x;
}
// int min=x->n;
p = x;
while (p->sibling != NULL) {
if ((p->sibling)->n < min) {
min = (p->sibling)->n;
t = p;
x = p->sibling;
}
p = p->sibling;
}
if (t == NULL && x->sibling == NULL)
H1 = NULL;
else if (t == NULL)
H1 = x->sibling;
else if (t->sibling == NULL)
t = NULL;
else
t->sibling = x->sibling;
if (x->child != NULL) {
REVERT_LIST(x->child);
(x->child)->sibling = NULL;
}
H = bin_HEAP_UNION(H1, Hr);
return x;
}
int REVERT_LIST(struct node* y) {
if (y->sibling != NULL) {
REVERT_LIST(y->sibling);
(y->sibling)->sibling = y;
} else {
Hr = y;
}
}
struct node* FIND_NODE(struct node* H, int k) {
struct node* x = H;
struct node* p = NULL;
if (x->n == k) {
p = x;
return p;
}
if (x->child != NULL && p == NULL) {

```

```

p = FIND_NODE(x->child, k);
}
if (x->sibling != NULL && p == NULL) {
p = FIND_NODE(x->sibling, k);
}
return p;
}
int bin_HEAP_DECREASE_KEY(struct node* H, int i, int k) {
int temp;
struct node* p;
struct node* y;
struct node* z;
p = FIND_NODE(H, i);
if (p == NULL) {
printf("\nINVALID CHOICE OF KEY TO BE REDUCED");
return 0;
}
if (k > p->n) {
printf("\nSORRY!THE NEW KEY IS GREATER THAN CURRENT ONE");
return 0;
}
p->n = k;
y = p;
z = p->parent;
while (z != NULL && y->n < z->n) {
temp = y->n;
y->n = z->n;
z->n = temp;
y = z;
z = z->parent;
}
printf("\nKEY REDUCED SUCCESSFULLY!");
}
int bin_HEAP_DELETE(struct node* H, int k) {
struct node* np;
if (H == NULL) {
printf("\nHEAP EMPTY");
return 0;
}
bin_HEAP_DECREASE_KEY(H, k, -1000);
np = bin_HEAP_EXTRACT_MIN(H);
if (np != NULL)
printf("\nNODE DELETED SUCCESSFULLY");
}
int main() {
int i, n, m, l;
struct node* p;
struct node* np;

```

```

char ch;
printf("\nENTER THE NUMBER OF ELEMENTS:");
scanf("%d", &n);
printf("\nENTER THE ELEMENTS:\n");
for (i = 1; i <= n; i++) {
scanf("%d", &m);
np = CREATE_NODE(m);
H = bin_HEAP_INSERT(H, np);
}
DISPLAY(H);
do {
printf("\nMENU:-\n");
printf("\n1)INSERT AN ELEMENT\n2)EXTRACT THE MINIMUM KEY NODE\n3)DECREASE A NODEKEY\n
4)DELETE A NODE\n5)QUIT\n");
scanf("%d", &l);
switch (l) {
case 1:
do {
printf("\nENTER THE ELEMENT TO BE INSERTED:");
scanf("%d", &m);
p = CREATE_NODE(m);
H = bin_HEAP_INSERT(H, p);
printf("\nNOW THE HEAP IS:\n");
DISPLAY(H);
printf("\nINSERT MORE(N/Y)= \n");
fflush(stdin);
scanf("%c", &ch);
} while (ch == 'Y' || ch == 'y');
break;
case 2:
do {
printf("\nEXTRACTING THE MINIMUM KEY NODE");
p = bin_HEAP_EXTRACT_MIN(H);
if (p != NULL)
printf("\nTHE EXTRACTED NODE IS %d", p->n);
printf("\nNOW THE HEAP IS:\n");
DISPLAY(H);
printf("\nEXTRACT MORE(N/Y)\n");
fflush(stdin);
scanf("%c", &ch);
} while (ch == 'Y' || ch == 'y');
break;
case 3:
do {
printf("\nENTER THE KEY OF THE NODE TO BE DECREASED:");
scanf("%d", &m);
printf("\nENTER THE NEW KEY : ");
scanf("%d", &l);

```

```

bin_HEAP_DECREASE_KEY(H, m, l);
printf("\nNOW THE HEAP IS:\n");
DISPLAY(H);
printf("\nDECREASE MORE(N/Y)\n");
fflush(stdin);
scanf("%c", &ch);
} while (ch == 'Y' || ch == 'y');
break;
case 4:
do {
printf("\nENTER THE KEY TO BE DELETED: ");
scanf("%d", &m);
bin_HEAP_DELETE(H, m);
printf("\nDELETE MORE(N/Y)\n");
fflush(stdin);
scanf("%c", &ch);
} while (ch == 'y' || ch == 'Y');
break;
case 5:
printf("\nTHANK U SIR\n");
break;
default:
printf("\nINVALID ENTRY...TRY AGAIN....\n");
}
} while (l != 5);
}

```

OUTPUT:

ENTER THE NUMBER OF ELEMENTS:4

ENTER THE ELEMENTS:

62

87

17

66

THE ROOT NODES ARE:-

17

MENU:-

1)INSERT AN ELEMENT

2)EXTRACT THE MINIMUM KEY NODE

3)DECREASE A NODEKEY

4)DELETE A NODE

5)QUIT

1

ENTER THE ELEMENT TO BE INSERTED:59

NOW THE HEAP IS:

THE ROOT NODES ARE:-

59-->17

INSERT MORE(N/Y)=

N

MENU:-

1)INSERT AN ELEMENT

2)EXTRACT THE MINIMUM KEY NODE

3)DECREASE A NODEKEY

4)DELETE A NODE

5)QUIT

2

EXTRACTING THE MINIMUM KEY NODE

THE EXTRACTED NODE IS 17

NOW THE HEAP IS:

THE ROOT NODES ARE:-

59

EXTRACT MORE(N/Y)

N

MENU:-

1)INSERT AN ELEMENT

2)EXTRACT THE MINIMUM KEY NODE

3)DECREASE A NODEKEY

4)DELETE A NODE





5)QUIT

3

ENTER THE KEY OF THE NODE TO BE DECREASED:66

ENTER THE NEW KEY : 08

INVALID CHOICE OF KEY TO BE REDUCED

master*   0  0  0

NOW THE HEAP IS:

THE ROOT NODES ARE:-

59

DECREASE MORE(N/Y)

N

MENU:-

- 1)INSERT AN ELEMENT
 - 2)EXTRACT THE MINIMUM KEY NODE
 - 3)DECREASE A NODEKEY
 - 4)DELETE A NODE
 - 5)QUIT
- 4

ENTER THE KEY TO BE DELETED: 87

INVALID CHOICE OF KEY TO BE REDUCED
NODE DELETED SUCCESSFULLY
DELETE MORE(N/Y)
N

ENTER THE KEY TO BE DELETED: 87

INVALID CHOICE OF KEY TO BE REDUCED
NODE DELETED SUCCESSFULLY
DELETE MORE(N/Y)
N

ENTER THE KEY TO BE DELETED: 87

ENTER THE KEY TO BE DELETED: 87

NODE DELETED SUCCESSFULLY

DELETE MORE(N/Y)

N

MENU:-

- 1)INSERT AN ELEMENT
 - 2)EXTRACT THE MINIMUM KEY NODE
 - 3)DECREASE A NODEKEY
- NODE DELETED SUCCESSFULLY
DELETE MORE(N/Y)
N

MENU:-

- 1)INSERT AN ELEMENT
- 2)EXTRACT THE MINIMUM KEY NODE
- 3)DECREASE A NODEKEY
- 4)DELETE A NODE
- 5)QUIT

MENU:-

- 1)INSERT AN ELEMENT
 - 2)EXTRACT THE MINIMUM KEY NODE
 - 3)DECREASE A NODEKEY
 - 4)DELETE A NODE
 - 5)QUIT
- 5

- 1)INSERT AN ELEMENT
- 2)EXTRACT THE MINIMUM KEY NODE
- 3)DECREASE A NODEKEY

4)DELETE A NODE
5)QUIT
5

5

PS C:\Users\10582\Desktop\KMCLU_ACADEMIC\5 semester\DAA> █

5. Implementation of an application of Dynamic Programming.

0/1 Knapsack problem program

//DP is an algorithmic technique used in computer science and mathematics to solve complex problems by breaking them down into smaller overlapping subproblems.

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

```
// A utility function that returns
```

```
// maximum of two integers
```

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

```
// Returns the maximum value that can be
```

```
// put in a knapsack of capacity W
```

```
int knapSack(int W, int wt[], int val[], int n)
```

```
{
```

```
// Base Case
```

```
if (n == 0 || W == 0)
```

```
return 0;
```

```
// If weight of the nth item is more than
```

```
// Knapsack capacity W, then this item cannot
```

```
// be included in the optimal solution
```

```
if (wt[n - 1] > W)
```

```
return knapSack(W, wt, val, n - 1);
```

```
// Return the maximum of two cases:
```

```
// (1) nth item included
```

```
// (2) not included
```

```
else
```

```
return max( val[n - 1] + knapSack(W - wt[n - 1], wt, val, n - 1),
```

```
knapSack(W, wt, val, n - 1));
```

```
}
```

```
// Driver code
```

```
int main()
```

```
{
```

```
int val[] = { 60, 100, 120 };
```

```
int wt[] = { 10, 20, 30 };
```

```
int W = 50;
```

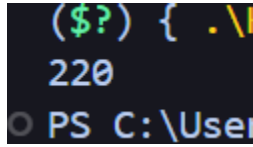
```
int n = sizeof(val) / sizeof(val[0]);
```

```
printf("%d", knapSack(W, wt, val, n));
```

```
return 0;
```

```
}
```

OUTPUT:



```
($?) { .\V  
220  
PS C:\User
```

6. Implementation of an application of Greedy Algorithm.

```
#include <stdio.h>
#include <stdlib.h>
#define MAX_TREE_HT 50
struct MinHNode {
    char item; unsigned freq;
    struct MinHNode *left, *right;
};

struct MinHeap { unsigned size; unsigned capacity;
    struct MinHNode **array;
};

// Create nodes
struct MinHNode *newNode(char item, unsigned freq) {
    struct MinHNode *temp = (struct MinHNode *)malloc(sizeof(struct MinHNode));

    temp->left = temp->right = NULL; temp->item = item;
    temp->freq = freq;

    return temp;
}

// Create min heap
struct MinHeap *createMinH(unsigned capacity) {
    struct MinHeap *minHeap = (struct MinHeap *)malloc(sizeof(struct MinHeap)); minHeap->size = 0;
    minHeap->capacity = capacity;

    minHeap->array = (struct MinHNode **)malloc(minHeap->capacity * sizeof(struct MinHNode *)); return
    minHeap;
}

// Function to swap
```

```

void swapMinHNode(struct MinHNode **a, struct MinHNode **b) {

struct MinHNode *t = *a;
*a = *b;
*b = t;
}

// Heapify
void minHeapify(struct MinHeap *minHeap, int idx) { int smallest = idx;
int left = 2 * idx + 1; int right = 2 * idx + 2;

if (left < minHeap->size && minHeap->array[left]->freq < minHeap->array[smallest]->freq) smallest = left;

if (right < minHeap->size && minHeap->array[right]->freq < minHeap->array[smallest]->freq) smallest =
right;

if (smallest != idx) {
swapMinHNode(&minHeap->array[smallest], &minHeap->array[idx]); minHeapify(minHeap, smallest);
}
}

// Check if size is 1
int checkSizeOne(struct MinHeap *minHeap) { return (minHeap->size == 1);
}

// Extract min
struct MinHNode *extractMin(struct MinHeap *minHeap) { struct MinHNode *temp = minHeap-
>array[0];
minHeap->array[0] = minHeap->array[minHeap->size - 1];

--minHeap->size; minHeapify(minHeap, 0);
return temp;
}

// Insertion function
void insertMinHeap(struct MinHeap *minHeap, struct MinHNode *minHeapNode) {
++minHeap->size;
int i = minHeap->size - 1;

while (i && minHeapNode->freq < minHeap->array[(i - 1) / 2]->freq) { minHeap->array[i] = minHeap-
>array[(i - 1) / 2];
i = (i - 1) / 2;
}

minHeap->array[i] = minHeapNode;

```

```

}
// Print the array
void printArray(int arr[], int n) { int i;
for (i = 0; i < n; ++i) printf("%d", arr[i]);

printf("\n");
}
void buildMinHeap(struct MinHeap *minHeap) { int n = minHeap->size - 1;
int i;

for (i = (n - 1) / 2; i >= 0; --i) minHeapify(minHeap, i);
}

int isLeaf(struct MinHNode *root) { return !(root->left) && !(root->right);
}
struct MinHeap *createAndBuildMinHeap(char item[], int freq[], int size) { struct MinHeap *minHeap =
createMinH(size);

for (int i = 0; i < size; ++i)
minHeap->array[i] = newNode(item[i], freq[i]);

minHeap->size = size; buildMinHeap(minHeap);

return minHeap;
}

struct MinHNode *buildHuffmanTree(char item[], int freq[], int size) { struct MinHNode *left, *right,
*top;
struct MinHeap *minHeap = createAndBuildMinHeap(item, freq, size);

while (!checkSizeOne(minHeap)) { left = extractMin(minHeap); right = extractMin(minHeap);
top = newNode('$', left->freq + right->freq); top->left = left;
top->right = right;

insertMinHeap(minHeap, top);
}
return extractMin(minHeap);
}
void printHCodes(struct MinHNode *root, int arr[], int top) { if (root->left) {
arr[top] = 0;

printHCodes(root->left, arr, top + 1);
}
if (root->right) { arr[top] = 1;

```

```

    printHCodes(root->right, arr, top + 1);
}
if (isLeaf(root)) {
    printf(" %c | ", root->item);
    printArray(arr, top);
}
}

```

// Wrapper function

```

void HuffmanCodes(char item[], int freq[], int size) {
    struct MinHNode *root = buildHuffmanTree(item, freq, size);
    int arr[MAX_TREE_HT], top = 0;
    printHCodes(root, arr, top);
}

```

```

int main() {
    char arr[] = {'A', 'B', 'C', 'D'};
    int freq[] = {5, 1, 6, 3};

```

```

    int size = sizeof(arr) / sizeof(arr[0]);
    printf(" Char | Huffman code "); printf("\n\n");

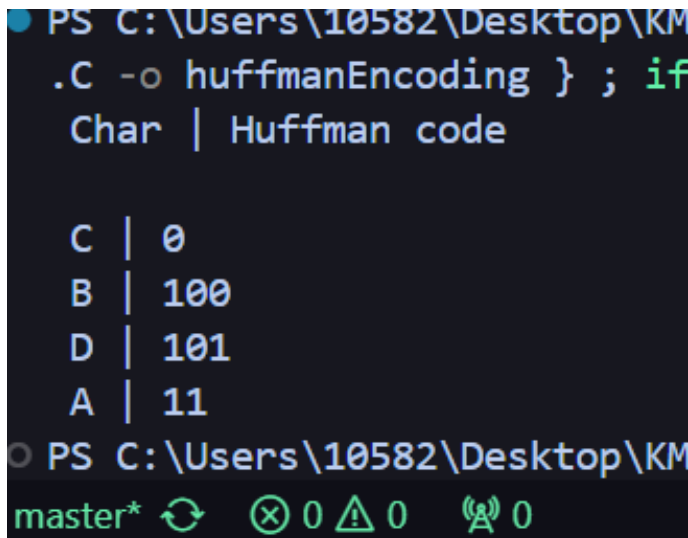
```

```

    HuffmanCodes(arr, freq, size);
}

```

OUTPUT:



```

PS C:\Users\10582\Desktop\KM
.C -o huffmanEncoding } ; if
Char | Huffman code

C | 0
B | 100
D | 101
A | 11
PS C:\Users\10582\Desktop\KM
master* 0 0 0

```

7. Implementation of Minimum Spanning Tree Algorithm.

Minimum Spanning Tree using Prim's Algorithm

```
#include <stdio.h>
#include <limits.h>

#define V 5

// Function to find the vertex with the minimum key value
int minKey(int key[], int mstSet[]) {
    int min = INT_MAX, min_index;

    for (int v = 0; v < V; v++)
        if (mstSet[v] == 0 && key[v] < min)
            min = key[v], min_index = v;

    return min_index;
}

// Function to print the constructed MST
void printMST(int parent[], int n, int graph[V][V]) {
    printf("Edge  Weight\n");
    for (int i = 1; i < V; i++)
        printf("%d - %d  %d \n", parent[i], i, graph[i][parent[i]]);
}

// Function to construct and print MST using Prim's algorithm
void primMST(int graph[V][V]) {
    int parent[V]; // Array to store the constructed MST
    int key[V];    // Key values used to pick minimum weight edge
    int mstSet[V]; // To represent set of vertices included in MST

    // Initialize all keys as infinite and mstSet[] as false
    for (int i = 0; i < V; i++) {
        key[i] = INT_MAX;
        mstSet[i] = 0;
    }

    // Always include the first vertex in MST
    key[0] = 0; // Make key 0 to pick it first
    parent[0] = -1; // First node is always the root of MST

    // MST will have V vertices
    for (int count = 0; count < V - 1; count++) {
```

```

// Pick the minimum key vertex not yet included in MST
int u = minKey(key, mstSet);

// Add the picked vertex to the MST set
mstSet[u] = 1;

// Update key value and parent index of adjacent vertices
for (int v = 0; v < V; v++) {
    // Update key only if graph[u][v] is non-zero, v is not in mstSet,
    // and the new weight is smaller than the current key
    if (graph[u][v] && mstSet[v] == 0 && graph[u][v] < key[v]) {
        parent[v] = u;
        key[v] = graph[u][v];
    }
}

// Print the constructed MST
printMST(parent, V, graph);
}

int main() {
    /* Let us create the following graph:
        2  3
        (0)--(1)--(2)
         | / \ |
        6| 8 5 |7
         | /  \ |
        (3)----- (4)
          9
    */
    int graph[V][V] = {
        { 0, 2, 0, 6, 0 },
        { 2, 0, 3, 8, 5 },
        { 0, 3, 0, 0, 7 },
        { 6, 8, 0, 0, 9 },
        { 0, 5, 7, 9, 0 }
    };

    // Run Prim's algorithm
    primMST(graph);

    return 0;
}

```


OUTPUT:

```
PS C:\Users\1058
ree.c -o minimum
Edge    Weight
0 - 1    2
1 - 2    3
0 - 3    6
1 - 4    5
PS C:\Users\1058
```

8. Implementation of Single-pair shortest path Algorithm.

Find Shortest Path using Dijkstra's Algorithm

```
#include <stdio.h>
#include <limits.h>
// Number of vertices in the graph
#define V 9
// A utility function to find the vertex with minimum distance value, from
// the set of vertices not yet included in shortest path tree
int minDistance(int dist[], int sptSet[]) {
    // Initialize min value
    int min = INT_MAX, min_index;
    int v;
    for (v = 0; v < V; v++)
        if (sptSet[v] == 0 && dist[v] <= min)
            min = dist[v], min_index = v;
    return min_index;
}
// A utility function to print the constructed distance array
void printSolution(int dist[], int n) {
    printf("Vertex Distance from Source\n");
    int i;
    for (i = 0; i < V; i++)
        printf("%d \t\t %d\n", i, dist[i]);
}
// Function that implements Dijkstra's single source shortest path algorithm
// for a graph represented using adjacency matrix representation
```

```

void dijkstra(int graph[V][V], int src) {
    int dist[V]; // The output array. dist[i] will hold the shortest
    // distance from src to i
    int sptSet[V]; // sptSet[i] will 1 if vertex i is included in shortest
    // path tree or shortest distance from src to i is finalized
    // Initialize all distances as INFINITE and sptSet[] as 0
    int i, count, v;
    for (i = 0; i < V; i++)
        dist[i] = INT_MAX, sptSet[i] = 0;
    // Distance of source vertex from itself is always 0
    dist[src] = 0;
    // Find shortest path for all vertices
    for (count = 0; count < V - 1; count++) {
        // Pick the minimum distance vertex from the set of vertices not
        // yet processed. u is always equal to src in first iteration.
        int u = minDistance(dist, sptSet);
        // Mark the picked vertex as processed
        sptSet[u] = 1;
        // Update dist value of the adjacent vertices of the picked vertex.
        for (v = 0; v < V; v++)
            // Update dist[v] only if is not in sptSet, there is an edge from
            // u to v, and total weight of path from src to v through u is
            // smaller than current value of dist[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];
    }
    // print the constructed distance array
    printSolution(dist, V);
}

// driver program to test above function
int main() {
    /* Let us create the example graph discussed above */
    int graph[V][V] = {{0, 4, 0, 0, 0, 0, 0, 8, 0},
        {4, 0, 8, 0, 0, 0, 0, 11, 0},
        {0, 8, 0, 7, 0, 4, 0, 0, 2},
        {0, 0, 7, 0, 9, 14, 0, 0, 0},
        {0, 0, 0, 9, 0, 10, 0, 0, 0},
        {0, 0, 4, 0, 10, 0, 2, 0, 0},
        {0, 0, 0, 14, 0, 2, 0, 1, 6},
        {8, 11, 0, 0, 0, 0, 1, 0, 7},
        {0, 0, 2, 0, 0, 0, 6, 7, 0}
    };
    dijkstra(graph, 0);
}

```

```
return 0;  
}
```

OUTPUT:

```
ngDijkstraAlgo.c - shortest path using  
Vertex Distance from Source  
0 0  
1 4  
2 12  
3 19  
4 21  
5 11  
6 9  
7 8  
8 14  
PS C:\Users\10582\Desktop\KMCLU ACAD
```

9. Implementation of All-pair shortest path Algorithm.

Implement Floyd Warshall Algorithm

// all pair Shorting path Algorithm using Floyd Warshall Algorithm

```
#include <stdio.h>  
#include  
<stdlib.h>  
  
void floydWarshall(int **graph, int n)  
{  
    int i, j, k;  
    for (k = 0; k < n; k++)  
    {  
        for (i = 0; i < n; i++)  
        {  
            for (j = 0; j < n; j++)  
            {  
                if (graph[i][j] > graph[i][k] + graph[k][j])
```

```

        graph[i][j] = graph[i][k] + graph[k][j];
    }
}
}
}

```

```

int main(void)
{
    int n, i, j;
    printf("Enter the number of vertices: ");
    scanf("%d", &n);
    int **graph = (int **)malloc((long unsigned) n * sizeof(int *));
    for (i = 0; i < n; i++)
    {
        graph[i] = (int *)malloc((long unsigned) n * sizeof(int));
    }

    for (i = 0; i < n; i++)
    {
        for (j = 0; j < n; j++)
        {
            if (i == j)
                graph[i][j] = 0;
            else
                graph[i][j] = 100;
        }
    }

    printf("Enter the edges: \n");
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < n; j++)
        {
            printf("[%d][%d]: ", i, j);
            scanf("%d", &graph[i][j]);
        }
    }

    printf("The original graph is:\n");
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < n; j++)
        {

```

```

        printf("%d ", graph[i][j]);
    }

    printf("\n");
}

floydWarshall(graph, n);
printf("The shortest path matrix is:\n");
for (i = 0; i < n; i++)
{
    for (j = 0; j < n; j++)
    {
        printf("%d ", graph[i][j]);
    }

    printf("\n");
}

return 0;
}

```

OUTPUT:

```

Enter the number of vertices: 2
Enter the edges:
[0][0]: 89
[0][1]: 78
[1][0]: 23
[1][1]: 12
The original graph is:
89 78
23 12
The shortest path matrix is:
89 78
23 12
PS C:\Users\10582\Desktop\KMCLU_ACADEMIC\5 semester\DAA>

```

10. Implementation of String Matching Algorithm.

```
#include<stdio.h>
int main() {
    char str1[30], str2[30];
    int i;
    printf("\nEnter two strings :");
    gets(str1);
    gets(str2);
    i = 0;
    while (str1[i] == str2[i] && str1[i] != '\0')
        i++;
    if (str1[i] > str2[i])
        printf("str1 > str2");
    else if (str1[i] < str2[i])
        printf("str1 < str2");
    else
        printf("str1 = str2");
    return (0);
}
```

OUTPUT:

```
) { gcc StringMatchingAlgorithm.c -o StringMatchingAlgori

Enter two strings :a
a
str1 = str2
PS C:\Users\10582\Desktop\KMCLU_ACADEMIC\5 semester\DAA>
) { gcc StringMatchingAlgorithm.c -o StringMatchingAlgori

Enter two strings :ert
abt
str1 > str2
) { gcc StringMatchingAlgorithm.c -o StringMatchingAlgori

Enter two strings :apl
mpl
str1 < str2
PS C:\Users\10582\Desktop\KMCLU_ACADEMIC\5 semester\DAA>
```