COEP TECHNOLOGICAL UNIVERSITY (COEP Tech)
A Unitary Public University of Government of Maharashtra
(Formerly College of Engineering Pune (COEP))

END Semester Examination

SOLUTION SET

			Marks
Q 1	**a**	In order to concatenate two linked list in O(1) time, which variation of linked list can be used? Answer : A **Doubly Circular Linked List** or a **Circular Linked List**	1
	b	What is the worst-case time complexity of inserting a node in a sorted doubly linked list? Answer: **O(n)**	1
	c	In linked list implementation of queue, if only front pointer is maintained, which of the queue operation(s) would take worst case linear time? Answer: **Enqueue**	1
Q 2	**a**	`#include<stdio.h>` `typedef struct data{` `  char x,y,z;` `}data;` `int main(){` `  data p = {'1', '0', 'a'+2};` `  data *q = &p;` `  printf ("%c, %c", *((char*)q+1), *((char*)q+2));` `  return 0;` `}` Write the output of above code. Answer: 0, c	2
	b	What is the output of the code given below? Assume the standard definition of stack functions. `#include <stdio.h>` `#include "stack.h"` `/* assume that stack doesn't get full */` `int main() {` `  stack s;` `  int i;` `  init(&s);` `  for(i = 0; i < 8; i++)` `  if(i % 3 == 0)` `  push(&s, i + 1);` `  if(i % 5 == 0)` `  push(&s, i - 1);` `  while(!isempty(&s))` `  printf("%d\n", pop(&s));`	2

```
    return 0;
}

Answer : 7 4 1
```

c Consider an unsorted array A = {5, 1, 4, 2, 8}. Sorting of elements is done using bubble sort. How many passes will it require to get the array sorted. — 2

Note: Write only numeric values as answer.

Answer : 4 passes

Q 3 **a** You are given a mathematical expression in **postfix notation**. Implement `evaluate_postfix() function` which evaluates the postfix expression using a **stack** data structure and returns an integer result. Assume the required stack operations. The function prototype is given below. — 3

```
int evaluate_postfix(char* expression);
```

Note : Operands and operators are separated by one space.

Answer : Implementation can vary according to logic.

```
int evaluate_postfix(char* expression) {
    Stack s;
    init(&s);  // Initialize the stack

    // Tokenize the expression based on spaces
    char* token = strtok(expression, " ");
    while (token != NULL) {
        if (isdigit(token[0])) {  // If token is a number
            // Convert string to integer and push onto the stack
            push(&s, atoi(token));
        } else {  // If token is an operator
            int b = pop(&s);  // Pop two operands
            int a = pop(&s);

            // Apply the operator and push the result back onto
the stack
            switch (token[0]) {
                case '+':
                    push(&s, a + b);
                    break;
                case '-':
                    push(&s, a - b);
                    break;
                case '*':
                    push(&s, a * b);
                    break;
                case '/':
                    if (b != 0) {
                        push(&s, a / b);
                    } else {
```

```
                        printf("Error: Division by zero.\n");
                        return -1;
                    }
                    break;
                default:
                    printf("Invalid operator encountered: %c\n",
token[0]);
                    return -1;
            }
        }
        token = strtok(NULL, " ");  // Get the next token
    }

    // The result is the last element on the stack
    return pop(&s);  // This will return the final result
}
```

b Write following functions in C with suitable prototypes for ADT Circular Singly Linked List : — 4

init_SLL() **(0.5 marks)** // initializes circular singly linked list of integers
append( ) **(1 mark)** // to add an element in the end of the list.
traverse() **(0.5 mark)** // to display all the elements of the list starting from first element to last.
remove_duplicates() **(2 marks)** /* The functions removes a duplicate node keeping only one node so that elements of node are unique.

For example, if the list is: {1, 2, 3, 2, 1} after the function is invoked the list changes to: {1, 2, 3 } */

You are free to include more functions if required .

Answer :

```
// Function to remove duplicates from the circular singly linked
list
void remove_duplicates(CLL* list) {
    if (list->head == NULL) return; // Empty list

    Node* current = list->head;
    do {
        Node* prev = current;
        Node* temp = current->next;
        while (temp != list->head) {
            if (current->data == temp->data) {
                // Duplicate found, remove it
                prev->next = temp->next;
                free(temp);
                temp = prev->next; // Move to next node
```

		`` } else { prev = temp; temp = temp->next; } } current = current->next; } while (current != list->head); } ```	
	c	Finishing the interiors of a lecture hall consists of several steps, such as laying electrical cables, installing audio-visual equipment, attaching the blackboard, etc. Suppose the steps are named as A, B, C, D, F and G. There is a directed edge from step 'X' to step 'Y' iff 'X' has to completed before 'Y'. Below is the order in which work can proceeded: A must happen before B B must happen before C C must happen before D D must happen before G A must happen before E E must happen before F E must happen before D D must happen before F F must happen before G What is the minimum number of days required to complete the interiors, if step takes a day to complete and independent steps can be completed parallelly? Answer : 5 days	2
Q 4	**a**	You are given an ADT stack with **push** and **pop** operations. Implement an ADT **queue** using two instances of stack data structures and their operations. Let the queue be represented by q and the stacks used to implement the queue be stack1 and stack2. Implement the following operations for the queue: 1. `void init_queue(Queue* q);` // Initializes the queue q by creating two empty stacks stack1 and stack2. (0.5 mark) 2. `void enqueue(Queue* q, int data);` // Adds an element to the end of the queue using stack1. (1 mark) 3. `int dequeue(Queue* q);` // Removes the element from the front of the queue (1 mark) 4. `void display_queue(Queue* q);` // Displays the elements of the queue. (0.5 mark) Include the structure for both Queue and Stack in your solution.	3
	b	Design and implement a Heap ADT in C to perform Heap Sort on an array of integers. **Function Specifications:** • `Heap* CreateHeap(int maxSize)` //Initializes a new heap structure with the specified maximum size. Returns a pointer to the created heap. • `void Insert(Heap* heap, int value).` //Inserts the given value into the heap while maintaining the max-heap property. • `void Heapify(Heap* heap, int* arr, int n)` //Converts the given array of size n into a max-heap and stores it in the heap.	4

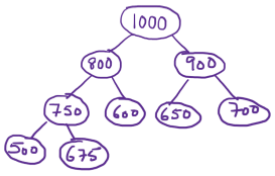
		• `void HeapSort(int* arr, int n)` //Sorts the array in ascending order using the heap.	
	c	You are given two polynomials represented by linked lists, where each node in the list represents a term in the polynomial with its coefficient and power of the variable. Write a C function to add these two polynomials by combining the terms with the same power and return the resultant polynomial in the form of a linked list. Implement the following operations for the Polynomial ADT: **1.** Define the **structure for the polynomial list node**: Each node should store the coefficient, the power of the variable, and pointers to the next node. **(0.5 marks)** 2. `void init_list(Polynomial *p);` //Initializes an empty linked list for the polynomial. **(0.5 marks)** **3.** `void add_term(Polynomial *p, int coefficient, int power);` //Adds a term with the specified coefficient and power at the end of the polynomial list**. (1 mark)** **4.** `Polynomial add_polynomials(Polynomial *p1, Polynomial *p2);` //Performs the addition of two polynomial lists, p1 and p2, by adding the coefficients of terms with the same power. Stores the result in a new linked list and returns it. **(1 mark)** **5.** `void display_polynomial(Polynomial p);` //Displays the polynomial in the standard format (e.g., 5x^2 + 3x + 2). **(1 mark)**	4
Q 5	**a**	Implement an ADT for a queue using a doubly circular linked list. The queue should maintain both a head pointer (to the first element) and a tail pointer (to the last element) of the sequence. Implement the following functions. Write your structure for Queue. 1. `void init_queue(Queue* q);` //Initializes an empty queue. 2. `void enqueue(Queue* q, int data);` //Adds an element with the specified data to the end of the queue. Updates both the head and tail pointers as necessary. 3. `int dequeue(Queue* q);` //Removes the element from the front of the queue and returns its data. Updates the head and tail pointers appropriately. 4. `int is_empty(Queue* q);` //Checks if the queue is empty. Returns 1 if it is empty, and 0 otherwise. 5. `void display_queue(Queue* q);` //Displays all elements in the queue from front to back. 6. `int is_full(Queue* q);` //A trivial function that returns 0, assuming the queue is never full.	5
	b	Write a recursive C function to verify whether a given binary tree is a Binary Search Tree (BST). (Mention the tree implementation used i.e., Array or Pointer). The Binary Tree structure is given below. `typedef struct {` `  Node* root;  // Pointer to the root node of the binary tree` `} BT;` Implement the following function: `int is_bst(BT* t);` The above function Returns 1 if the tree is a Binary Search Tree, and 0 otherwise.	5

The function should use recursion to validate that the tree meets the conditions of a Binary Search Tree. Consider all nodes and subtrees to ensure the global ordering property holds.

Answer:

```
int is_bst(BT* t) {
    if (t == NULL || t->root == NULL) {
        return 1;  // An empty tree is a valid BST
    }

    return is_bst_helper(t->root, INT_MIN, INT_MAX);
}

int is_bst_helper(Node* node, int min, int max) {
    // Base case: If the node is NULL, it's a valid BST (empty
tree is valid)
    if (node == NULL) {
        return 1;
    }

    // Check if the current node's data is within the valid range
    if (node->data <= min || node->data >= max) {
        return 0;  // Invalid BST if the node's value is outside
the range
    }

    // Recursively check the left and right subtrees
    return is_bst_helper(node->left, min, node->data) &&
           is_bst_helper(node->right, node->data, max);
}
```

c A tree of nodes having block size of memory in KB is available as shown in an example in the diagram below: 5



A request for **m KB** (say for example 580 KB) of dynamic memory is received by OS. Write a function **findBlock()** to return the block size which best fits the requested size of memory from the tree in this case 600KB.

Note: Parameters to the function are tree and block size.

Answer:

```
int findBlock(Node* root, int m) {
    // Variable to store the best fit block size
    int x = -1;
    Node *p = root;
    // Traverse the tree to find the best fitting block
    while (p != NULL) {
        if (p->data >= m) {

            if (x == -1 || p->data < x) {
                x = p->data;
            }
            // Move to the left to find potentially smaller
fitting blocks
            p = p->left;
        } else {
            // Move to the right for larger blocks
            p = p->right;
        }
    }

    return x;
}
```

Q6	**a**	Design an ADT for a city's bus transportation network using a graph represented by an adjacency list. Each bus stop is a node, and each route between stops has a specific distance in kilometres. Implement the following functions: 1. `InitializeGraph(Graph *g, int numOfStops)` //Initializes the graph with the specified number of stops. **[0.5 Mark]** 2. `AddRoute(Graph *g , int stop1, int stop2, int distance)` //Adds a route between two stops with the given distance**. [2 Marks]** 3. `RemoveRoute(Graph *g, int stop1, int stop2)` //Removes an existing route between two stops**. [1 Mark]** 4. `GetConnectedStops(Graph *g, int stop)` //Returns a list of stops directly connected to the given stop. **[2 Marks]** 5. `ShortestPath(Graph *g, int startStop, int endStop)` //Finds the shortest path between two stops using Dijkstra's algorithm**. [2 Marks]** **6.** `DisplayNetwork(Graph g)` //Prints the entire network, showing each stop and its connections with distances. **[0.5 Mark]** The structure for the Graph is given below. Use the same. `// Structure for each node in the adjacency list` `typedef struct AdjNode {` `  int stop;  // Bus stop identifier` `  int distance;  // Distance to the connected stop` `  struct AdjNode* next;  // Pointer to the next connected stop` `} AdjNode;` `// Structure for the graph`	8

```
typedef struct Graph {
    int numStops;           // Total number of bus stops
    AdjNode** adjList;      // Array of adjacency lists for each
stop
} Graph;
```

Answer:

```
void GetConnectedStops(Graph *g, int stop) {
    AdjNode* p = g->adjList[stop];

    if (p == NULL) {
        return;
    }

    printf("Stops connected to stop %d: ", stop);
    while (p != NULL) {
        printf("%d (Distance: %d km) ", p->stop, p->distance);
        p = p->next;
    }
}
```

b Implement a C function that detects whether a cycle exists in an undirected graph. The graph is represented by an ADT which allows adding edges and performing a Depth-First Search (DFS) for cycle detection. 4

Your task is to implement a function `has_cycle()` that returns 1 if the graph contains a cycle, and 0 if it does not. Use the below definition of graph and adjacency list structure

// Definition of the graph structure

```
typedef struct {
    int V; // Number of vertices
    struct Node** adjList; // Adjacency list
}Graph;
```

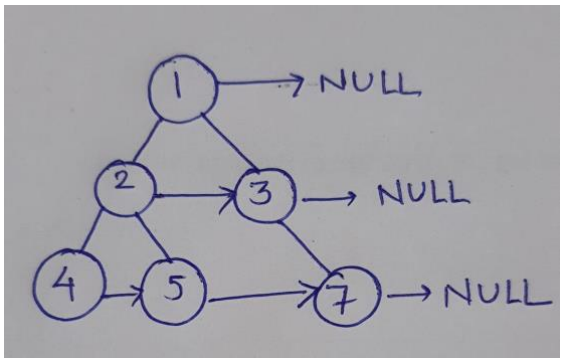
// Structure for adjacency list node

```
typedef struct Node {
    int vertex;
    struct Node* next;
}Node;
```

// Function to detect cycle in the graph using DFS

```
int has_cycle(Graph* graph);
```

Comment on the time complexity of the implemented function to detect cycle.

	c	Consider the Binary Tree having structure as below: `typedef struct mynode {` `  int val;` `  Node *left;` `  Node *right;` `  Node *next;` `}mynode` Write a recursive or non-recursive function : `mynode* connect(mynode* root);` The function `connect()` should set next pointer to point to its next right node. If there is no next right node, the next pointer should be set to NULL. Example:  Answer: `mynode* connect(mynode* root) {` `    // Base case: If the tree is empty, return NULL` `    if (root == NULL) {` `        return NULL;` `    }` `    // Connect left and right children` `    if (root->left && root->right) {` `        root->left->next = root->right;  // Connect the left child to the right child` `    }` `    // If the current node has a next pointer, connect the right child to the next node's left child` `    if (root->next) {` `        if (root->right) {` `            root->right->next = root->next->left;` `        }` `        if (root->left) {` `            root->left->next = root->next->left;` `        }` `    }` `    // Recursively connect the left and right subtrees` `    connect(root->left);`	4

```
    connect(root->right);

    return root;
}
```

********** ALL THE BEST **********