Data Structures and algorithms

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3D12

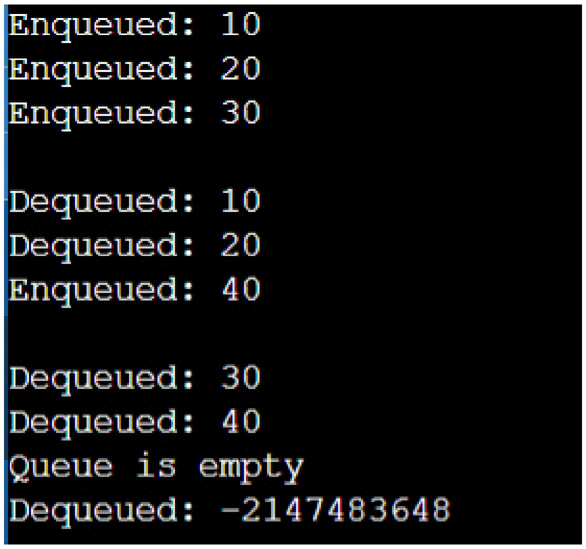
EXTRA QUES

Q1. Implement queue using a stack and a function call stack.

```
#include <stdio.h>
#include <stdlib.h>
#include <limits.h>
// --- Basic Stack Implementation ---
typedef struct Stack {
   int top;
   unsigned capacity;
   int* array;
} Stack;
Stack* createStack(unsigned capacity) {
   Stack* stack = (Stack*)malloc(sizeof(Stack));
   if (!stack) return NULL;
   stack->capacity = capacity;
   stack->top = -1;
   stack->array = (int*)malloc(stack->capacity * sizeof(int));
   if (!stack->array) {
      free(stack);
      return NULL;
   }
```

```
    return stack;
}
int isStackEmpty(Stack* stack) {
    return stack->top == -1;
}
void push(Stack* stack, int item) {
    if (stack->top == (int)stack->capacity - 1) {
        printf("Stack Overflow\n");
        return;
    }
    stack->array[++stack->top] = item;
}
int pop(Stack* stack) {
    if (isStackEmpty(stack)) {
        return INT_MIN; // Error value
    }
    return stack->array[stack->top--];
}
// --- Queue Implementation using a Stack ---
typedef struct Queue {
    Stack* s1;
} Queue;
Queue* createQueue(unsigned capacity) {
    Queue* q = (Queue*)malloc(sizeof(Queue));
    q->s1 = createStack(capacity);
    return q;
}
// Enqueue is a simple push operation
void enqueue(Queue* q, int item) {
    push(q->s1, item);

    printf("Enqueued: %d\n", item);

}

// Recursive helper function to find the bottom of the stack

int dequeueRecursive(Stack* s) {

    // Base case: If there's only one item, pop and return it

    if (isStackEmpty(s)) {

        return INT_MIN; // Should not happen in the main dequeue logic

    }

    int item = pop(s);

    if (isStackEmpty(s)) {

        return item; // This is the bottom element

    }

    // Recursive step: go deeper

    int bottom_item = dequeueRecursive(s);

    // After the recursive call returns, push the item back

    // This happens on the way "up" the call stack

    push(s, item);

    retuRn bottom_item;

}

// Dequeue operation

int dequeue(Queue* q) {

    if (isStackEmpty(q->s1)) {

        printf("Queue is empty\n");

        return INT_MIN;

    }

    return dequeueRecursive(q->s1);

}

// Free all allocated memory
```

```
void freeQueue(Queue* q) {
    free(q->s1->array);
    free(q->s1);
    free(q);
}
int main() {
    Queue* q = createQueue(10);
    enqueue(q, 10);
    enqueue(q, 20);
    enqueue(q, 30);
    printf("\nDequeued: %d\n", dequeue(q));
    printf("Dequeued: %d\n", dequeue(q));
    enqueue(q, 40);
    printf("\nDequeued: %d\n", dequeue(q));
    printf("Dequeued: %d\n", dequeue(q));
    printf("Dequeued: %d\n", dequeue(q)); // Trying to dequeue from empty queue
    freeQueue(q);
    return 0;
}
```



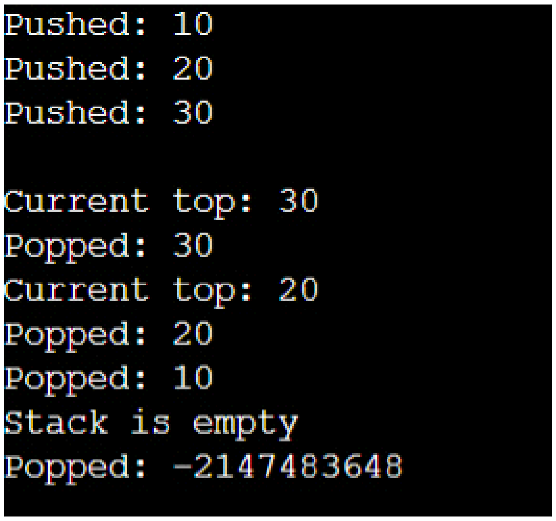
```
Enqueued: 10
Enqueued: 20
Enqueued: 30

Dequeued: 10
Dequeued: 20
Enqueued: 40

Dequeued: 30
Dequeued: 40
Queue is empty
Dequeued: -2147483648
```

Q2. Implement a stack using 2 queues.

```
#include <stdio.h>

#include <stdlib.h>

#include <limits.h>

// --- Basic Queue Implementation ---

typedef struct QueueNode {

   int data;

   struct QueueNode* next;

} QueueNode;

typedef struct Queue {

   QueueNode *front, *rear;

   int size;

} Queue;

Queue* createQueue() {

   Queue* q = (Queue*)malloc(sizeof(Queue));

   q->front = q->rear = NULL;

   q->size = 0;

   return q;

}

int isQueueEmpty(Queue* q) {

   return q->size == 0;

}

void enqueue(Queue* q, int item) {

   QueueNode* temp = (QueueNode*)malloc(sizeof(QueueNode));

   temp->data = item;

   temp->next = NULL;
```

```
    q->size++;
    if (q->rear == NULL) {
        q->front = q->rear = temp;
        return;
    }
    q->rear->next = temp;
    q->rear = temp;
}
int dequeue(Queue* q) {
    if (isQueueEmpty(q)) {
        return INT_MIN;
    }
    QueueNode* temp = q->front;
    int item = temp->data;
    q->front = q->front->next;
    if (q->front == NULL) {
        q->rear = NULL;
    }
    free(temp);
    q->size--;
    return item;
}
// --- Stack Implementation using two Queues ---
typedef struct Stack {
    Queue *q1, *q2;
} Stack;
Stack* createStack() {
    Stack* s = (Stack*)malloc(sizeof(Stack));
    s->q1 = createQueue(); // The main queue
    s->q2 = createQueue(); // The helper queue
    return s;
}
int isStackEmpty_sq(Stack* s) {
    return isQueueEmpty(s->q1);
}
// Push operation is a simple enqueue to q1
void push_sq(Stack* s, int item) {
    enqueue(s->q1, item);
    printf("Pushed: %d\n", item);
}
// Pop is the costly operation
int pop_sq(Stack* s) {
    if (isStackEmpty_sq(s)) {
        printf("Stack is empty\n");
        return INT_MIN;
    }
    // Move all elements but the last one from q1 to q2
    while (s->q1->size > 1) {
        enqueue(s->q2, dequeue(s->q1));
    }
    // The last element in q1 is the one to be popped
    int item = dequeue(s->q1);
    // Swap the names of q1 and q2 to make q2 the main queue
    Queue* temp = s->q1;
    s->q1 = s->q2;
    s->q2 = temp;
    return item;
}
```

```
int top_sq(Stack* s) {
     if (isStackEmpty_sq(s)) {
        printf("Stack is empty\n");
        return INT_MIN;
    }
    // Similar logic to pop, but we must re-enqueue the last element
    while (s->q1->size > 1) {
        enqueue(s->q2, dequeue(s->q1));
    }
    int item = dequeue(s->q1);
    enqueue(s->q2, item); // Put it back
    Queue* temp = s->q1;
    s->q1 = s->q2;
    s->q2 = temp;
    return item;
}
// Free all allocated memory
void freeStack(Stack* s) {
    // Free any remaining nodes in both queues
    while (!isQueueEmpty(s->q1)) dequeue(s->q1);
    while (!isQueueEmpty(s->q2)) dequeue(s->q2);
    free(s->q1);
    free(s->q2);
    free(s);
}
int main() {
    Stack* s = createStack();
    push_sq(s, 10);
    push_sq(s, 20);
    push_sq(s, 30);
    printf("\nCurrent top: %d\n", top_sq(s));
    printf("Popped: %d\n", pop_sq(s))
    printf("Current top: %d\n", top_sq(s));
    printf("Popped: %d\n", pop_sq(s));
    printf("Popped: %d\n", pop_sq(s));
    printf("Popped: %d\n", pop_sq(s)); // Trying to pop from empty stack
    freeStack(s);
    return 0;
}
```

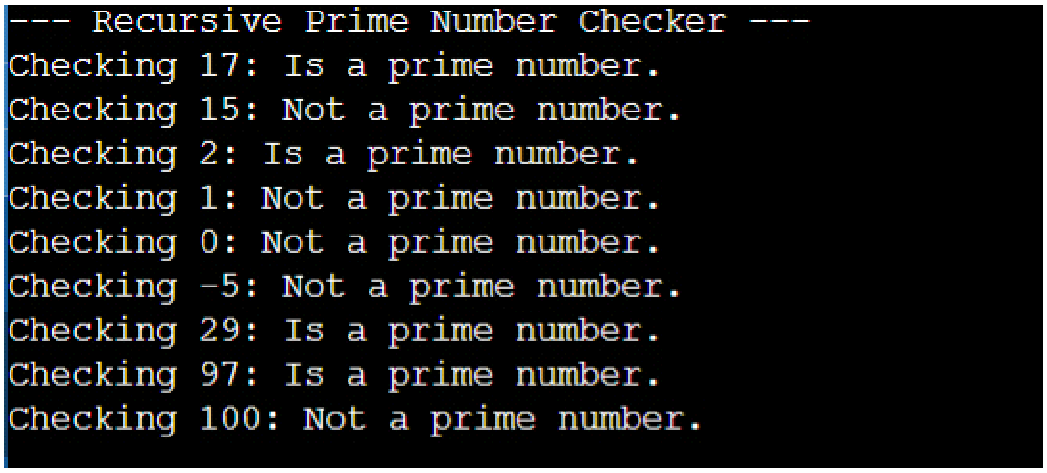


```
Pushed: 10
Pushed: 20
Pushed: 30

Current top: 30
Popped: 30
Current top: 20
Popped: 20
Popped: 10
Stack is empty
Popped: -2147483648
```

Q3. Write recursive function to determine if a number is a prime number.

```
#include <stdio.h>
#include <math.h> // Required for the sqrt() optimization
int is_prime_recursive(int n, int divisor) {
    // Base case 1: If the divisor reaches 1, no factors were found. The number is prime.
    if (divisor <= 1) {
        return 1; // True
    }
    // Base case 2: If n is divisible by the current divisor, it's not prime.
    if (n % divisor == 0) {
        return 0; // False
    }
    // Recursive step: Call the function again with the next smaller divisor.
    return is_prime_recursive(n, divisor - 1);
}
int main() {
    int test_nums[] = {17, 15, 2, 1, 0, -5, 29, 97, 100};
    int num_tests = sizeof(test_nums) / sizeof(test_nums[0]);
    printf("--- Recursive Prime Number Checker ---\n");
    for (int i = 0; i < num_tests; i++) {
        int n = test_nums[i];
        printf("Checking %d: ", n);
        // Initial checks must be handled before the first recursive call.
        if (n <= 1) {
            printf("Not a prime number.\n");
        } else if (n == 2) {
            printf("Is a prime number.\n"); // 2 is a special prime case
        } else {
            // Start the recursive check. We only need to check up to sqrt(n).
            if (is_prime_recursive(n, (int)sqrt(n))) {
                printf("Is a prime number.\n");
            } else {
                printf("Not a prime number.\n");
            }
        }
    }
    return 0;
```

}



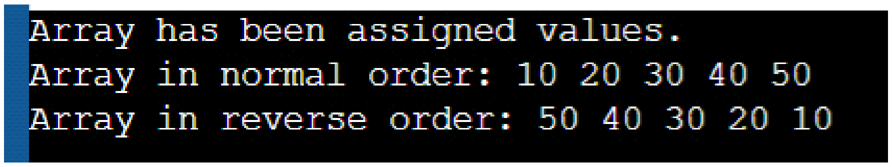
```
--- Recursive Prime Number Checker ---
Checking 17: Is a prime number.
Checking 15: Not a prime number.
Checking 2: Is a prime number.
Checking 1: Not a prime number.
Checking 0: Not a prime number.
Checking -5: Not a prime number.
Checking 29: Is a prime number.
Checking 97: Is a prime number.
Checking 100: Not a prime number.
```

Q4. Write recursive functions to assign the particular values to the array, and print the array in reverse and normal order.

```
#include <stdio.h>

#define MAX_SIZE 5

void assign_values_recursive(int *arr, int size) {

   // Base case: If there are no elements to process, stop.

   if (size <= 0) {

      return;

   }

   // Recurse first to process the smaller, preceding part of the array.

   assign_values_recursive(arr, size - 1);

   // Assign value to the current last element on the way back up the call stack.

   arr[size - 1] = size * 10;

}

void print_array_normal(const int *arr, int size) {

   // Base case: If the array segment is empty, stop.

   if (size <= 0) {

      return;
```

```
    }

    // Print the first element, then recurse on the rest of the array.

    printf("%d ", *arr);

    print_array_normal(arr + 1, size - 1);

}

void print_array_reverse(const int *arr, int size) {

    // Base case: If the array segment is empty, stop.

    if (size <= 0) {

        return;

    }

    // Recurse on the rest of the array first...

    print_array_reverse(arr + 1, size - 1);

    // ...then print the first element on the way back up the call stack.

    printf("%d ", *arr);

}

int main() {

    int my_array[MAX_SIZE];

    // 1. Assign values

    assign_values_recursive(my_array, MAX_SIZE);

    printf("Array has been assigned values.\n");

    // 2. Print in normal order

    printf("Array in normal order: ");

    print_array_normal(my_array, MAX_SIZE);

    printf("\n");

    // 3. Print in reverse order

    printf("Array in reverse order: ");

    print_array_reverse(my_array, MAX_SIZE);

    printf("\n");

    return 0;
```

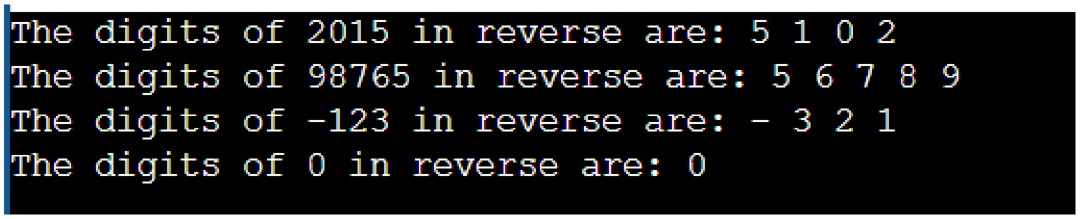
}


```
Array has been assigned values.
Array in normal order: 10 20 30 40 50
Array in reverse order: 50 40 30 20 10
```

Q5. Write recursive function to print the given number in reverse order: 2015.

```c
#include <stdio.h>
void print_digits_reverse(int n) {
  // Handle negative numbers by printing the sign and proceeding with the positive version.
  if (n < 0) {
    printf("- ");
    n = -n;
  }
  printf("%d ", n % 10);
  if (n / 10 > 0) {
    print_digits_reverse(n / 10);
  }
}
int main() {
  int num1 = 2015;
  printf("The digits of %d in reverse are: ", num1);
  print_digits_reverse(num1);
  printf("\n");
  int num2 = 98765;
  printf("The digits of %d in reverse are: ", num2);
  print_digits_reverse(num2);
  printf("\n");
  int num3 = -123;
```

```
    printf("The digits of %d in reverse are: ", num3);

    print_digits_reverse(num3);

    printf("\n");

    int num4 = 0;

    printf("The digits of %d in reverse are: ", num4);

    if (num4 == 0) {

        printf("0");

    } else {

        print_digits_reverse(num4);

    }

    printf("\n");

    return 0;

}
```



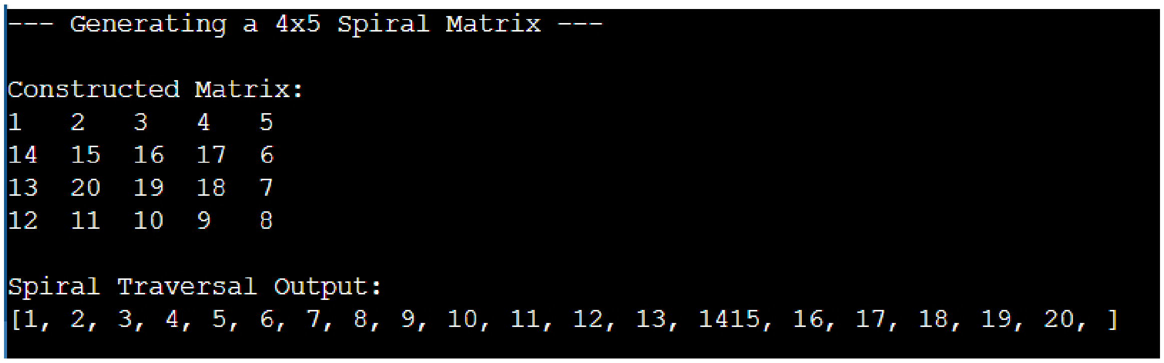
```
The digits of 2015 in reverse are: 5 1 0 2
The digits of 98765 in reverse are: 5 6 7 8 9
The digits of -123 in reverse are: - 3 2 1
The digits of 0 in reverse are: 0
```

Q6. Write a program to construct a spiral matrix using arrays.

```
#include <stdio.h>

#include <stdlib.h>

void printMatrix(int** matrix, int rows, int cols) {

    if (!matrix) return;

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

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

            printf("%-4d", matrix[i][j]); // Print with padding

        }

        printf("\n");
    }
}
void printSpiralOrder(int** matrix, int rows, int cols) {
    if (!matrix) return;
    int top = 0, bottom = rows - 1;
    int left = 0, right = cols - 1;
    printf("[");
    while (top <= bottom && left <= right) {
        // 1. Print top row (left to right)
        for (int i = left; i <= right; i++) {
            printf("%d", matrix[top][i]);
            if (top < bottom || i < right) printf(", ");
        }
        top++;
        // 2. Print right column (top to bottom)
        for (int i = top; i <= bottom; i++) {
            printf("%d", matrix[i][right]);
            if (left < right || i < bottom) printf(", ");
        }
        right--;
        // 3. Print bottom row (right to left)
        if (top <= bottom) {
            for (int i = right; i >= left; i--) {
                printf("%d", matrix[bottom][i]);
                if (left < right || i > left) printf(", ");
            }
            bottom--;
        }
        // 4. Print left column (bottom to top)
        if (left <= right) {
            for (int i = bottom; i >= top; i--) {
                printf("%d", matrix[i][left]);
                 if (i > top) printf(", ");
            }
            left++;
        }
    }
    printf("]\n");
}
int** generateSpiralMatrix(int rows, int cols) {
    // Allocate memory for the matrix
    int** matrix = (int**)malloc(rows * sizeof(int*));
    if (!matrix) return NULL;
    for (int i = 0; i < rows; i++) {
        matrix[i] = (int*)malloc(cols * sizeof(int));
        if (!matrix[i]) {
            // Cleanup on failure
            while (--i >= 0) free(matrix[i]);
            free(matrix);
            return NULL;
        }
    }

    int top = 0, bottom = rows - 1;
    int left = 0, right = cols - 1;
    int num = 1; // The number to place in the matrix

    while (top <= bottom && left <= right) {
```

```
    // 1. Fill top row
    for (int i = left; i <= right; i++) {
        matrix[top][i] = num++;
    }
    top++;

    // 2. Fill right column
    for (int i = top; i <= bottom; i++) {
        matrix[i][right] = num++;
    }
    right--;

    // 3. Fill bottom row (check boundary)
    if (top <= bottom) {
        for (int i = right; i >= left; i--) {
            matrix[bottom][i] = num++;
        }
        bottom--;
    }

    // 4. Fill left column (check boundary)
    if (left <= right) {
        for (int i = bottom; i >= top; i--) {
            matrix[i][left] = num++;
        }
        left++;
    }
}
return matrix;
```

```
}


void freeMatrix(int** matrix, int rows) {
    if (!matrix) return;
    for (int i = 0; i < rows; i++) {
        free(matrix[i]);
    }
    free(matrix);
}

int main() {
    int rows = 4;
    int cols = 5;

    printf("--- Generating a %dx%d Spiral Matrix ---\n\n", rows, cols);

    // 1. Generate the matrix
    int** spiral = generateSpiralMatrix(rows, cols);

    // 2. Print the generated matrix in grid form
    printf("Constructed Matrix:\n");
    printMatrix(spiral, rows, cols);

    // 3. Print the spiral traversal
    printf("\nSpiral Traversal Output:\n");
    printSpiralOrder(spiral, rows, cols);

    // 4. Clean up allocated memory
    freeMatrix(spiral, rows);


    return 0;

}
```



```
--- Generating a 4x5 Spiral Matrix ---

Constructed Matrix:
1   2   3   4   5
14  15  16  17  6
13  20  19  18  7
12  11  10  9   8

Spiral Traversal Output:
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 1415, 16, 17, 18, 19, 20, ]
```