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# KIRIRI WOMEN'S UNIVERSITY OF SCIENCE AND TECHNOLOGY
## UNIVERSITY EXAMINATION, 2024/2025 ACADEMIC YEAR
## SECOND YEAR, FIRST SEMESTER EXAMINATION
## FOR THE BACHELOR OF BUSINESS AND INFORMATION TECHNOLOGY
## KBI 2202 – DATA STRUCTURES AND ALGORITHMS

Date: 06TH December 2024
Time: 2:30PM – 4:30PM

**INSTRUCTIONS TO CANDIDATES**
**ANSWER QUESTION ONE (COMPULSORY) AND ANY OTHER TWO QUESTIONS**
**QUESTION ONE (30 MARKS)**

1. A friend has consulted you on coming up with a software for her fresh product shop. She wishes to ensure that all products take the shortest time possible, by selling the products in the order they came.
   i) Describe the data types you would recommend for this implementation. Give reasons for your answer (3 Marks)
   ii) Explain the data structure that you would recommend for this implementation. Give reasons for your answer (3 Marks)
2. Asymptotic notations are commonly used to describe the complexity of an algorithm with respect to the input size n.For each function f(n) below, give an asymptotic upper bound using big-Oh notation
   i) $f(n) = 10n^3 - 7n^3 + 14n^2$ (2 Marks)
   ii) $f(n) = 10n^3 - 10n^3 + 7n^2$ (2 Marks)
   iii) $f(n) = \log(7n^2)$ (2 Marks)
3. Solve this recurrence relation using Master's Theorem (4 Marks)

$$T(n) = 2T(n/2) + n$$

4. Convert the following Infix Expression, **X * Y,** into Prefix and Post Expressions. (4 Marks)
5. Give the output of the following Code implementation (5 Marks)

```
x = 15
y = 6

# Addition Operator
print('x + y = ', x + y)

# Subtraction Operator
print('x - y = ', x - y)

# Multiplication Operator
print('x * y = ', x * y)

# Division Operator
print('x / y = ', x / y) # True Division
print('x // y =', x//y) # Class Division
```

6. You have a set of Kenyan notes with values {5, 10, 20, 50, 100, 200, 500} and you need to give a minimum number of notes to someone for a change of 1000. Describe a naive greedy algorithm approach to achieve your task objective (5 Marks)

## QUESTION TWO (20 MARKS)

a) Given an empty stack called "Thestack" with a maxsize of 5, using a diagram clearly illustrate the status (position of the pointer top, the cell occupied by the element - where appropriate or the element displayed -where appropriate) of the stack when we;

i) Top ( ) (2 Marks)
ii) Push(13) (1 Mark)
iii) Push(20) (1 Mark)
iv) Pop() (1 Mark)
v) Push () (2 Marks)
vi) Pop() (1 Mark)
vii) Pop(20) (2 Marks)

b) Given a grid of size n*m (n is the number of rows and m is the number of columns in the grid) consisting of '0's (Water) and '1's(Land). Find the number of islands of the following input; (4 Marks)

**Input:** M[][] = {{'1', '1', '0', '0', '0'},
{'0', '1', '0', '0', '1'},
{'1', '0', '0', '1', '1'},
{'0', '0', '0', '0', '0'},
{'1', '0', '1', '1', '0'}}

c) Solve the Police catch Genz protestors using arrays and greedy approach. The constraints are

Given an array of size n that has the following specifications:

- Each element in the array contains either a policeman or a Genz protestor.
- Each policeman can catch only one Genz protestor.
- A policeman cannot catch a Genz who is more than K units away from the policeman.

We need to find the maximum number of Genz protestors that can be caught using these inputs.

i) Input1 : arr[] = {'P', 'G', 'G', 'P', 'G'}, k = 1 (2 Marks)
ii) Input2 : arr[] = {'G', 'G', 'P', 'P', 'G', 'P'}, k = 2 (2 Marks)
iii) Input3 : arr[] = {'P', 'G', 'P', 'G', 'G', 'P'}, k = 3 (2 Marks)

## QUESTION THREE (20 MARKS)

a) Sort the following data elements using the quick sort method. 45, 23, 89, 12, 67, 34, 78, 11(4 Marks)

b) A ride-sharing company is designing a new system to manage and optimize its operations. The company wants to handle a variety of tasks, including managing the customer ride requests, tracking vehicle locations, and optimizing routes for the drivers. The company is considering different data structures (stacks, queues, graphs, trees, etc.) to efficiently solve the problems below. You are tasked with choosing the most appropriate data structure for each requirement and justifying your decision.

i) When customers request a ride, their requests are handled on a first-come, first-served basis. Each customer's request should be processed in the order it arrives. If a customer cancels a ride, their request should be deleted. Give the data structure that should be used to manage the ride requests to ensure that they are processed in the correct order. Explain why. (4 Marks)

ii) List the data structure that should be used to keep track of a driver's location history? Explain how this helps in retrieving the latest location efficiently. (4 Marks)

iii) Once a driver is assigned to a customer, the system must calculate the shortest route from the driver's current location to the customer's location. Give the data structure that should be used to represent the city map and compute the shortest route between the driver and the customer (2 Marks)

c) Given the string "abracadarba", determine the longest prefix which is also a suffix manually. Indicate all steps clearly. (6 Marks)

## QUESTION FOUR (20 MARKS)

a) You are tasked with creating a system for scheduling workshops at a conference where each workshop has a start and end time. Your job is to maximize the number of workshops that can be attended without overlapping. Given the following workshop start and end times, clearly determine the maximum number of non-overlapping workshops using the Greedy approach.

(10 Marks)

| Workshop | Start Time | End Time |
|---|---|---|
| W1 | 9:00 | 11:00 |
| W2 | 10:30 | 12:30 |
| W3 | 12:00 | 14:00 |
| W4 | 13:00 | 15:00 |
| W5 | 14:30 | 16:30 |

b) You are given a large text file containing the DNA sequences of various organisms. The task is to find if a given DNA pattern exists in the sequences and how many times it appears.
Assume the following is a DNA sequence:

- DNA: "ACGTACGTGACG"
- Pattern: "ACGT"

Use any pattern search algorithm to find how many times the pattern appears in the sequence.

(10 Marks)

## QUESTION FIVE (20 MARKS)

It is proposed to store a large number of records on a disk using Larsen's method so that any lookup can be done using only one disk transfer. All the records are of length 200 bytes and each contains a 20 byte key. The data is to be held on a single disk preformatted to contain 100,000,000 sectors each of size 4096 bytes. Reading multiple consecutive sectors is regarded as a single transfer.

a) Describe Larsen's algorithm in detail and, for the records and disk specified above, state the disk block size, the signature size and the amount of main memory that you would choose to use. (10 Marks)

b) Carefully estimate the maximum number of records that could reasonably be stored on the disk assuming the sizes you gave in part (a). (6 Marks)

c) Discuss the advantages and disadvantages of different signature sizes. (4 Marks)