



**Strathmore**  
UNIVERSITY

SCHOOL OF COMPUTING AND ENGINEERING SCIENCES  
BACHELOR OF SCIENCE IN COMPUTER NETWORKS AND CYBERSECURITY  
CNS 2102: DATA STRUCTURES AND ALGORITHMS  
END OF SEMESTER EXAMINATION

**Date: 23<sup>rd</sup> July 2024**

**Time: 15:30-17:30 Hours**

**INSTRUCTIONS**

1. Answer Question 1 (**Compulsory**) and any other **Two** Questions.
2. You may use **C++**, **Java**, **JavaScript** or **Python** in your programming solutions.
3. **In the calculations, show your workings for full marks.**

**Question 1: - Compulsory**

**30 Marks**

**(a)** Rank the given algorithmic functions in their right order of growth from **smallest** to the **largest**.

Use numbers as suggested in the table below to show the order. **(4 Marks)**

Algorithmic Function		Rank in order of growth (1 for the slowest growth and 4 for the fastest growth)
A.	$f(x) = 300n + 6$	
B.	$g(x) = 6n^2 + 1$	
C.	$O(n^2 \log n)$	
D.	$O(\log n)$	

**(b)** From the choices below, select the asymptotic relationship between  $n^k$  and  $c^n$  given that  $k$  and  $c$  are constants and  $k \geq 1$  and  $c > 1$ . **(2 Marks)**

**Choices:**

(A)  $n^k$  is  $O(c^n)$

(B)  $n^k$  is  $\Omega(c^n)$

(C)  $n^k$  is  $\theta(c^n)$

(c) From the choices below, select the asymptotic relationship between  $8^n$  and  $4^n$ . **(2 Marks)**

**Choices:**

(A)  $8^n$  is  $O(4^n)$

(B)  $8^n$  is  $\Omega(4^n)$

(C)  $8^n$  is  $\theta(4^n)$

(d) Asymptotically, is there a difference between a function  $f(x) = \log_2 n$  and another function  $f_1(x) = \log_{10} n$ ? Explain. **(2 Mark)**

(e) Fill in the blank spaces in the table below. Use **Big O** in all the expressions. **(4 Marks)**

	Algorithm	Best Time Complexity	Worst Time Complexity
1	Heap Sort		$O(n \log n)$
2	Bubble Sort	$O(n)$	
3	Quick Sort		$O(n^2)$
4	Exchange Sort		$O(n^2)$

(f) Explain why programmers choose to use Quick sort despite the better complexity in Heap Sort **(2 Marks)**

(g) Briefly explain the main difference between Bubble sort and Exchange sort **(2 Marks)**

(h) A loop invariant is some predicate (condition) that holds or is true for every iteration in the loop. Discuss the **three** properties of a loop invariant. **(3 Marks)**

(i) Discuss any **three** algorithm design techniques as used in Data Structures and Algorithms problem solving. **(3 Marks)**

(j) Consider the list given below and respond to the questions that follow.

**numbers = [20, 45, -10, 13, 489, 100]**

(i) Given a target of **110**, using Binary Search, calculate and return the index of the target in the list. **(4 Marks)**

(ii) Write a Linear Search function to return the index of the target named in (i) above. **(2 Marks)**

- (a) In the case study below, you are given a list of integers, and you are required to return the indices of two numbers that add to a specific given target without using the same number twice.

**For Example:**

Given **numbers** = [2, 7, 11, 15] and **target** = 9 you will **return** [0, 1] since **numbers** [0] + **numbers** [1] = 2 + 7 = 9

**Python Solution** is as seen below.

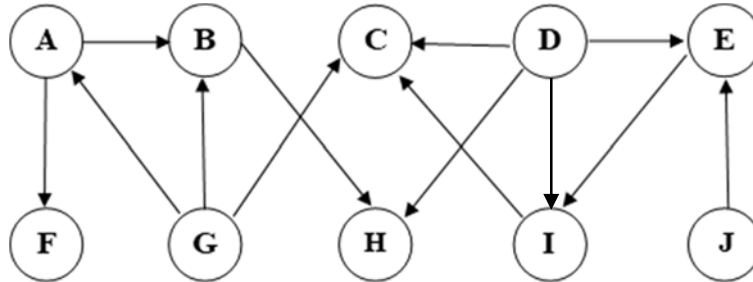
```
1 def two_sum(nums, target):
2     for i in range(len(nums)):
3         for j in range(i + 1, len(nums)):
4             if nums[j] == target - nums[i]:
5                 return [i, j]
6     raise ValueError("No two sum solution")
```

- (i) Calculate the time complexity of the solution above. (2 Marks)
- (ii) Rewrite the solution above to achieve a better time complexity (3 Marks)
- (b) A palindrome is a string that reads the same when reversed. For example, Mum, Dad and 101. Write a simple function that will return **True** if the parameter is a palindrome. (3 Marks)
- (c) To check if a number is prime, you need to determine if it has any divisors other than 1 and itself. Complete the function below to determine if **n** is prime or not. (4 Marks)

```
1 import math
2
3
4 new *
5 def is_prime(n: int) -> bool:
6     pass
```

- (d) Memoization is an optimization technique used primarily to speed up computer programs by storing the results of expensive function calls and returning the cached result when the same inputs occur again. Solve the Fibonacci problem using this technique. (3 Marks)

- (a) Consider the Direct Acyclic Graph (DAG) given below to answer the corresponding questions. Perform all operations from node A. Additionally, you may use a spanning tree or stacks in your solutions.



- (i) Briefly describe topological ordering in Graphs (1 Mark)
  - (ii) Using Depth First Search (DFS), topologically sort the DAG above (3 Marks)
  - (iii) Using Breadth First Search (BFS), topologically sort the DAG above (3 Marks)
- (b) Consider a **Binary Search Tree (BST)** having the following nodes with their corresponding values and respond to the questions that follow. Nodes = A → 50, B → 48, C → 60, D → 40, E → 49, F → 58, G → 64, H → 41, I → 61 and J → 65.

- (i) If A is the root Node, delete node A and draw the resulting tree T2. Explain the deletion (2 Marks)
- (ii) From the resulting tree T2 in (i) above, complete the table below to show the order of the given traversals. Use the **Alphabet letters** from the tree to show the order of traversals. (4 Marks)

No	Traversals	Order of Traversal
1	PreOrder	
2	PostOrder	
3	InOrder	
4	Level Order	

- (iii) Explain the time complexity of traversing a Binary Search Tree (BST) to locate a node. (2 Marks)

**Question 4: - Git and Version Control**

**15 Marks**

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**Instruction: Use commands in the practical sections.**

- (a) Explain the difference between Git and GitHub. (2 Marks)
- (b) Explain the difference between Git Remote and Git Origin (2 Marks)
- (c) Apart from GitHub, name any other Git Repository commonly used in the software development industry today (1 Mark)
- (d) You have joined a software engineering team to collaborate on a project with other team members working remotely. You have therefore been tasked setup the project files on your GitHub and local repositories in order to get started.
  - (i) Given that you have forked the project to <https://github.com/cnsinterns/codelabs>. Clone the project to your local drive /Users/cns\_intern/ (2 Marks)
  - (ii) The project only has one branch main, create another branch develop and merge the changes in main (2 Marks)
  - (iii) One of the team members requested for the changes you have made in your develop, explain how you would create a pull request to their repository. (2 Marks)
  - (iv) Differentiate between **git fetch** and **git pull** (2 Marks)
  - (v) Explain two uses of Git Rebase (2 Marks)

**Question 5: - General Knowledge and Analysis of Algorithms**

**15 Marks**

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- (a) Explain why recursion a bad idea for general programming solutions. (2 Marks)
- (b) Differentiate between a list, a dictionary (2 Marks)
- (c) Discuss **two** situations that when a queue can be considered full (2 Marks)
- (d) Explain the intersection point in the graph of linear search versus binary search (3 Marks)
- (e) Discuss two situations when you would use Red Black Trees (2 Marks)
- (f) Explain the use of **Pandas** and **NumPy** Python Libraries. (2 Marks)
- (g) Write a one-line command to install Pandas and NumPy in a Python Virtual Environment (2 Marks)