UNITED INTERNATIONAL UNIVERSITY (UIU)

Department of Computer Science and Engineering (CSE)

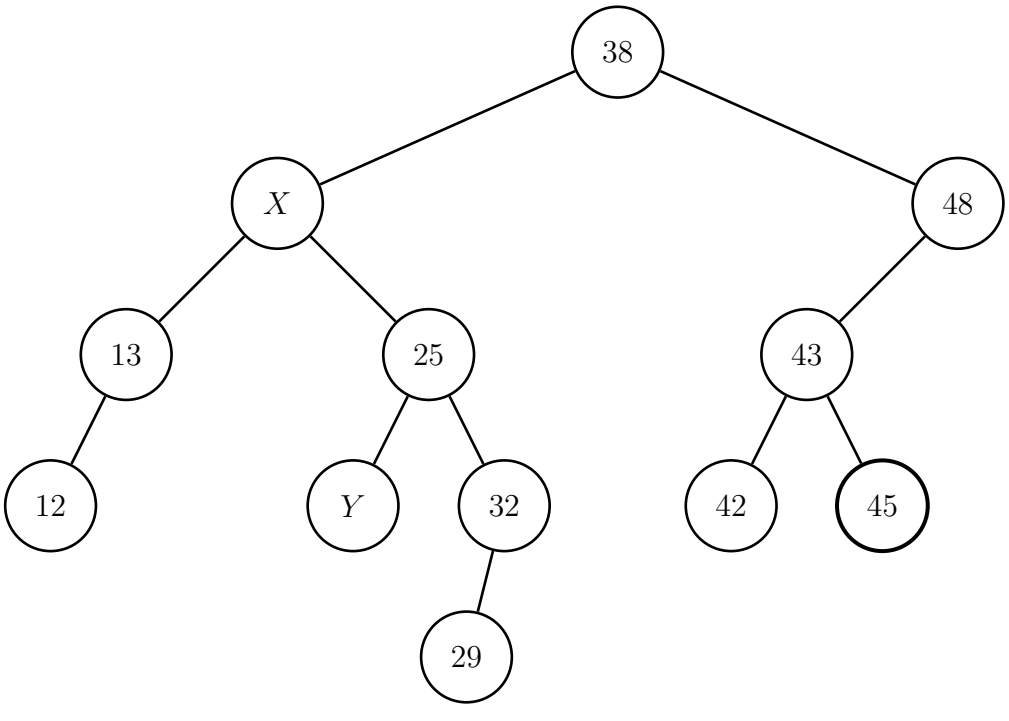
FINAL EXAMINATION **SPRING, 2025**
DURATION: 2 HOURS **FULL MARKS: 40**

CSE 2215: Data Structures and Algorithms I

Answer **all 5 (five)** questions. Figures in the right margin indicate full marks of questions.

[Any examinee found adopting unfair means will be expelled from the trimester/program according to UIU disciplinary rules.]

1. Check out the **binary search tree** below and answer the questions that follow. 5×2



   a) Locate the node with the value 45. Write the values of all its **ancestor** nodes.

   b) Is every **subtree** of a BST also a BST? Explain your answer briefly.

   c) Which **tree traversal method** can be used to print all the node values of the BST in ascending order? Explain your answer briefly.

   d) In the **worst-case scenario**, how many nodes have to be visited to find a value in this BST?

   e) If $Y = 17$, what are the possible values of X so that this tree remains a valid BST?

2. You are given the following array of strings: `["apple", "cat", "dog", "zebra", "ball"]`.

   Answer the following questions. When comparing two strings, use **lexicographical comparison** (e.g., "apple" < "banana", "car" < "cart").

   a) Convert the array into a **max-heap** and show the result. 3

   b) Insert the string "`monkey`" into the max-heap. Show the final heap after insertion. 2

   c) What is the **time complexity** of converting this max-heap array into a min-heap array? Justify your answer briefly. 3

3. Richard Hendricks has restarted Pied Piper and is now building a new browser called **PiperBrowse**. Gilfoyle, the Head of Security and Systems Architecture, reluctantly agreed to help with two features:

   - **Download Manager:** Multiple files are downloaded at the same time. As soon as a file finishes downloading, it is added to a data structure. Later, the files are processed (e.g., virus scanned) in the order they completed downloading.
   - **Tab Manager:** Each tab stores the history of pages visited in that tab. When the user clicks the "Back" button, they go back through the previously visited pages in reverse order.

   Usage Information:

   - Typically, 1–5 files are downloaded at once; up to 25 in heavy use.
   - Users usually visit 8–12 pages in a tab; power users may visit up to 50 pages.

   Answer the following questions:

   a) Which data structure between stack and queue should be used for the **Download Manager**? Explain your choice. 1.5

   b) Which data structure between stack and queue should be used for the **Tab Manager**? Explain your choice. 1.5

   c) Gilfoyle decides to implement both data structures using arrays. Describe how each can be implemented using an array, considering the maximum expected usage in each case. 3

   You don't need to write code–just describe how the array is used.

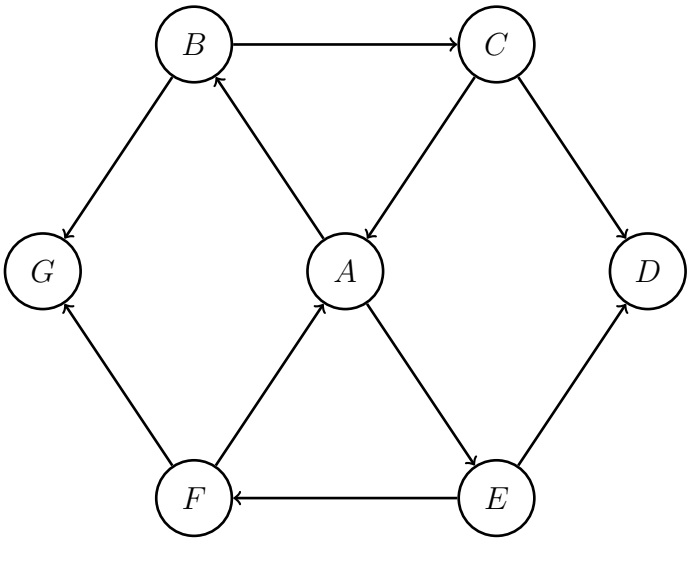
   d) What problem might occur if a user visits 51 pages in a tab? How can this issue be resolved? 2

4. Answer the following questions. 2×3

   a) Consider the postfix expression: `6 3 2 + 4 * + 5 2 - + 8 + * 9`
   Check whether this expression is valid or invalid. Justify your answer.

   b) Suppose you have a **fixed-size stack of length 6**.
   Write a valid postfix expression that will cause **stack overflow** during evaluation.

5. Rafi and Rubayet are exploring a large city made up of several districts connected by **one-way roads**. The structure of the city is shown in the figure below.



- **Rafi** wants to explore one district each day. He starts from his hometown and prefers to explore the closest districts first, moving outward gradually to farther places.
- **Rubayet** wants to explore all the districts in a single day. He picks a path and keeps going as far as he can without turning back, only returning when he reaches a dead end.
- When faced with multiple choices, both Rafi and Rubayet prefer to **break ties alphabetically** — choosing to explore 'A' before 'B', 'B' before 'C', and so on in case of a tie.

Answer the following questions based on their exploration styles:

a) Which graph traversal technique corresponds to **Rafi's** method of exploring? Briefly explain your answer. 1

b) How can Rafi and Rubayet avoid exploring the same district more than once? 2

c) Suppose you start at **district A**. Simulate how you would visit all the districts using **Rubayet's** exploration style. Use an appropriate data structure in your simulation. 3

d) Can you apply **topological sorting** to the graph below? Explain why or why not. 2