

CS101 Algorithms and Data Structures  
Fall 2023  
Homework 5

Due date: November 12, 2023, at 23:59

1. Please write your solutions in English.
2. Submit your solutions to [gradescope.com](https://gradescope.com).
3. Set your FULL name to your Chinese name and your STUDENT ID correctly in Account Settings.
4. If you want to submit a handwritten version, scan it clearly. **CamScanner** is recommended.
5. When submitting, match your solutions to the problems correctly.
6. No late submission will be accepted.
7. Violations to any of the above may result in zero points.

## 1. (12 points) Multiple Choices

Each question has **one or more** correct answer(s). Select all the correct answer(s). For each question, you will get 0 points if you select one or more wrong answers, but you will get 1 point if you select a non-empty subset of the correct answers.

Write your answers in the following table.

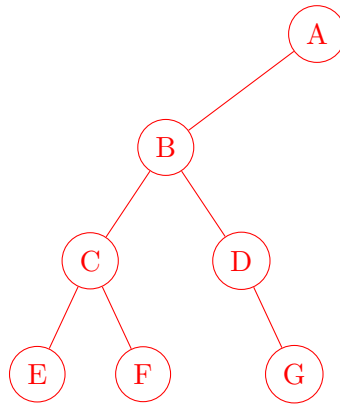
(a)	(b)	(c)	(d)	(e)	(f)
AC	AD	D	B	B	ABD

- (a) (2') Which of the following statements is/are true about **tree**?
- A. A tree with  $N$  nodes has  $N - 1$  edges.
  - B. The height of a tree is always positive.
  - C. Every node of a tree is either a leaf node or an internal node.
  - D. The degree and the depth of the root node should be 0.
- (b) (2') Which of the following statements is/are true about **binary tree**?
- A. In a binary tree, every non-root node has exactly one parent.
  - B. Every full binary tree is also a complete binary tree.
  - C. A full binary tree with  $n$  non-leaf nodes contains  $2n - 1$  total nodes.
  - D. A binary tree of height 0 is also perfect.
- (c) (2') Which of the following choices is/are  $\Theta(m)$  where  $m$  is the maximum length of the queue when traversing a tree with BFS?
- A. The total number of nodes in the tree.
  - B. The length of the deepest path from a leaf node to the root node.
  - C. The maximum degree of nodes in the tree.
  - D. The maximum number of nodes at a given depth of the tree.
- (d) (2') There exists two paths between any two different nodes in a tree with height more than 3.
- A. True.
  - B. False.
- (e) (2') The height of a tree is always equal to the maximum depth of nodes in the tree.
- A. True.
  - B. False.
- (f) (2') Which of the following statements is/are false?
- A. Nodes with the same depth are siblings.
  - B. Each node in the tree has exactly one parent pointing to it.
  - C. Given any node  $\alpha$  within a tree, the collection of  $\alpha$  and all of its descendants is a subtree of the tree with root  $\alpha$ .
  - D. The root node cannot be the descendent of any nodes.

2. (10 points) Generate a binary tree

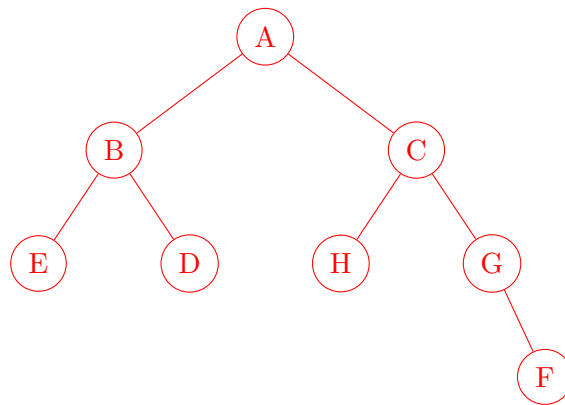
- (a) (4') Given the in-order and pre-order traversal of a binary tree T are **ECFBDGA** and **ABCEFDG** respectively.  
Draw the tree T.

**Solution:**



- (b) (4') Given the in-order and post-order traversal of a binary tree T are **EBDAHCGF** and **EDBHFGCA** respectively.  
Draw the tree T.

**Solution:**



- (c) (2') Given the pre-order and post-order traversal of a binary tree  $T$ , can you decide the tree  $T$ ? If yes, please describe an algorithm to construct  $T$ ; if no, please provide a counterexample.

**Solution:**

No. Given the pre-order of  $T$  is  $AB$ , and the post-order of  $T$  is  $BA$ , then the following two binary trees both match.

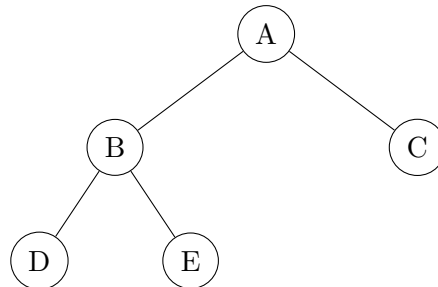


**3.** (10 points) Tree Structure and Traversal

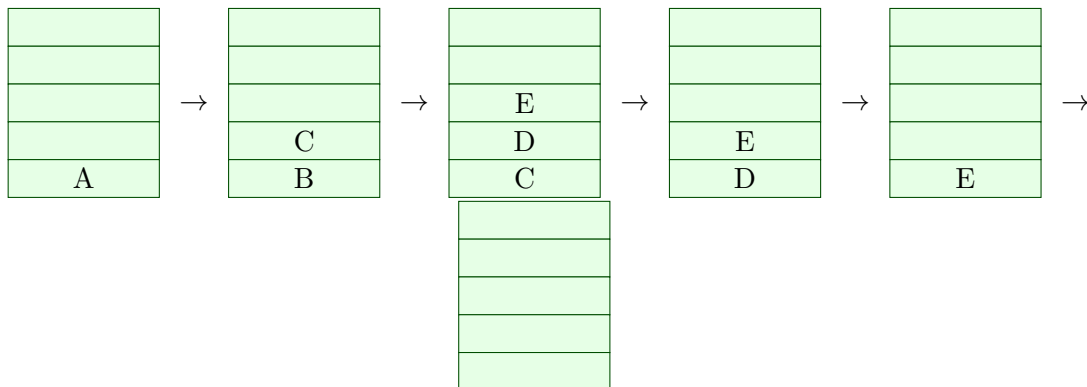
You should solve the below questions following these steps:

1. Decide on an appropriate **data structure** to implement the traversal.
2. When doing **Breadth First Traversal**, push children of a node into the data structure in alphabetical order.
3. Consider **popping an entry** and **pushing all its children** as one step.

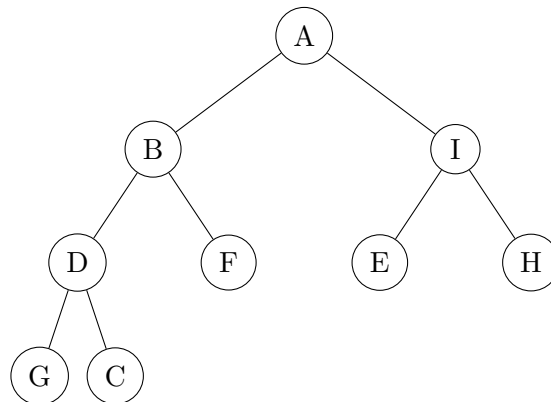
**Example:** Given a tree with root **A**:



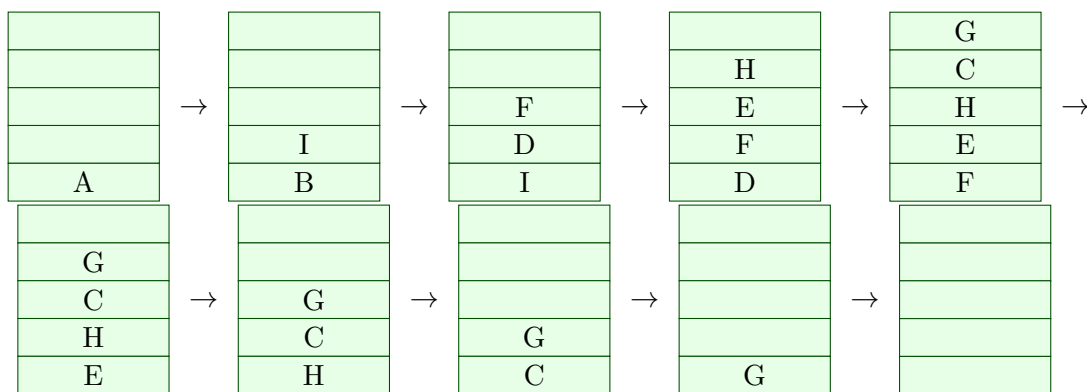
The process of doing **Breadth First Traversal** is:



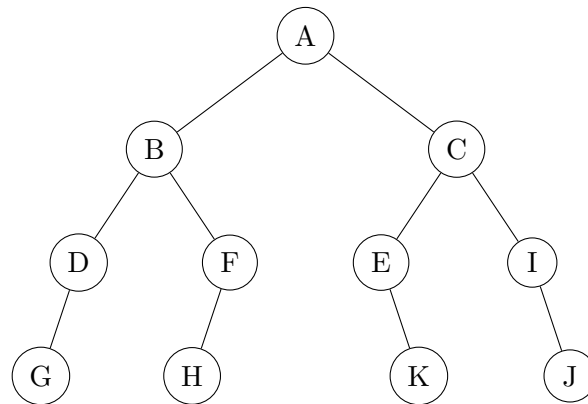
- (a) (5') Run **Breadth First Traversal** on the tree with root **A** and draw the whole process in the space below.



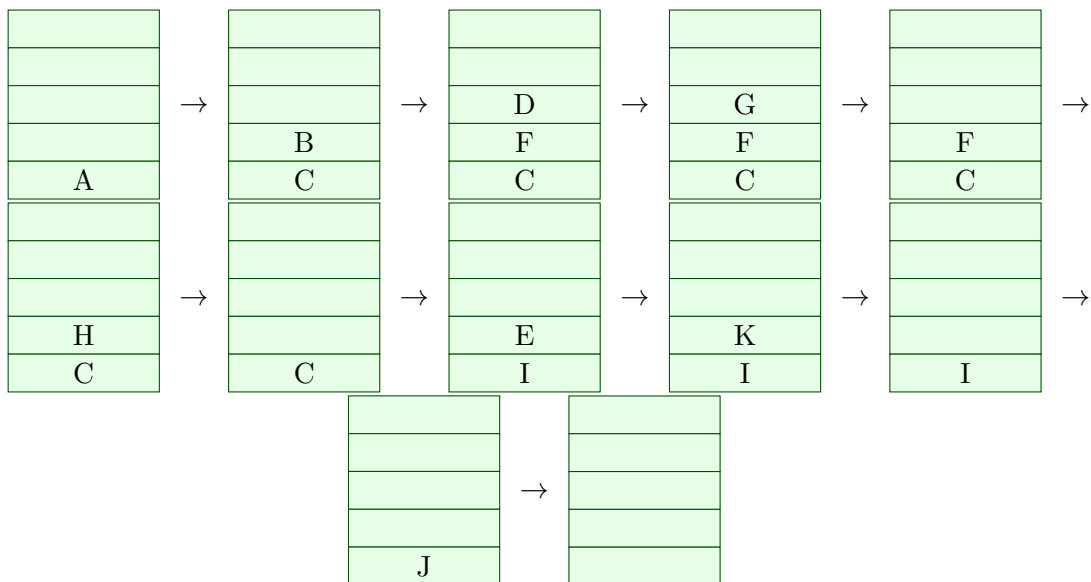
**Solution:**



- (b) (5') Run **Pre-order Depth First Traversal** on the tree with root **A** and draw the whole process in the space below.



**Solution:**



4. (10 points) Left Child Right Sibling

(a) (1') For every ordered tree, there is a unique representation of Left-child right-sibling format.

✓ True ☐ False

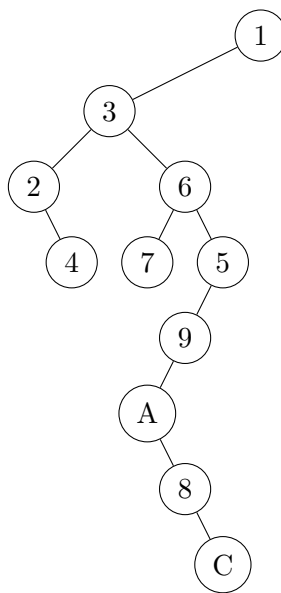
(b) (1') Pre-order traversal of the original tree is identical to the pre-order traversal of the Knuth transform.

✓ True ☐ False

(c) (1') Post-order traversal of the original tree is identical to the post-order traversal of the Knuth transform.

☐ True ✓ False

(d) (7') Transform the tree below with root 1 (in LCRS format) to N-ary format.



**Solution:**

