

# VE281

## Data Structures and Algorithms

### **Binary Tree Traversal**

#### **Learning Objectives:**

- Know the effect and procedure of pre-order, post-order, and in-order depth-first traversal
- Know the effect and procedure of level-order traversal

# Binary Tree Traversal

- Many binary tree operations are done by performing a **traversal** of the binary tree.
- In a traversal, each node of the binary tree is visited **exactly once**.
- During the visit of a node, all actions (making a clone, displaying, evaluating the operator, etc.) with respect to this node are taken.

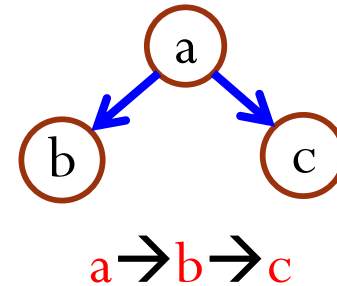
# Binary Tree Traversal Methods

- Depth-first traversal
  - Pre-order
  - Post-order
  - In-order
- Level-order traversal

# Pre-Order Depth-First Traversal

## Procedure

- Visit the node
- Visit its left subtree
- Visit its right subtree

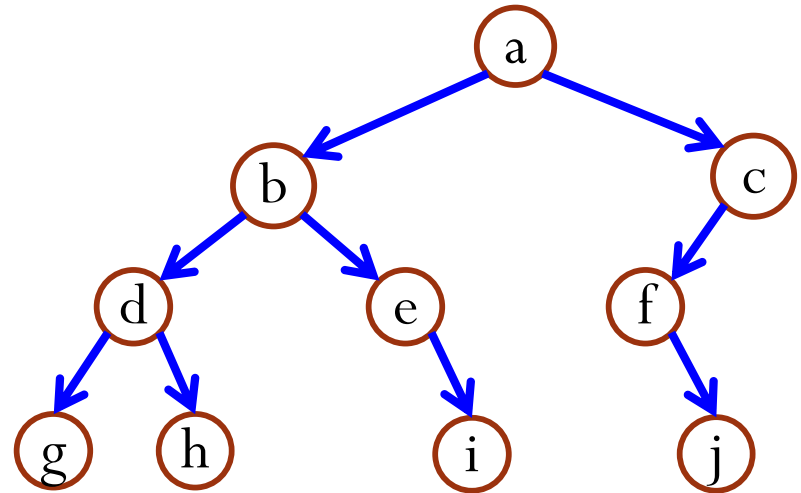



```
void preOrder(node *n) {  
    if(!n) return;  
    visit(n) ;  
    preOrder(n->left) ;  
    preOrder(n->right) ;  
}
```

# Pre-Order Depth-First Traversal

Example

a  
b  
d  
g  
h  
e  
i  
c  
f  
j

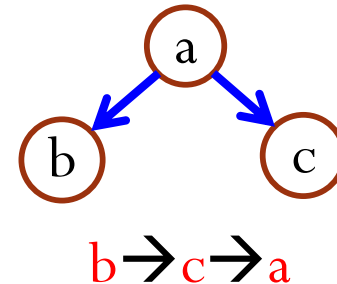


a → b → d → g → h → e → i → c → f → j

# Post-Order Depth-First Traversal

## Procedure

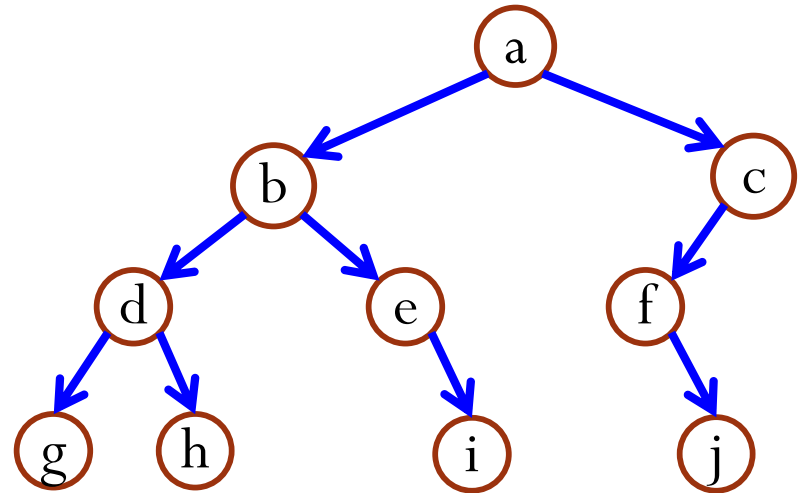
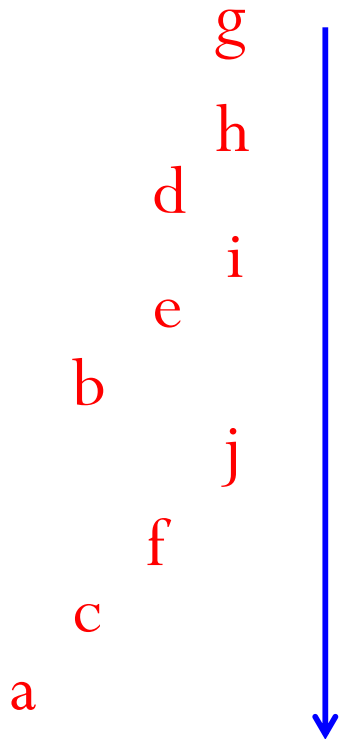
- Visit the left subtree
- Visit the right subtree
- Visit the node



```
void postOrder(node *n) {  
    if(!n) return;  
    postOrder(n->left);  
    postOrder(n->right);  
    visit(n);  
}
```

# Post-Order Depth-First Traversal

Example

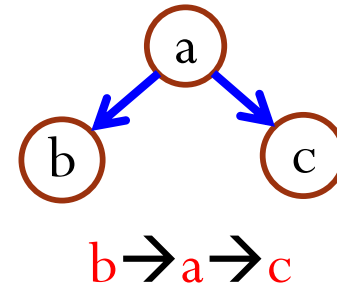


$g \rightarrow h \rightarrow d \rightarrow i \rightarrow e \rightarrow b \rightarrow j \rightarrow f \rightarrow c \rightarrow a$

# In-Order Depth-First Traversal

## Procedure

- Visit the left subtree
- Visit the node
- Visit the right subtree

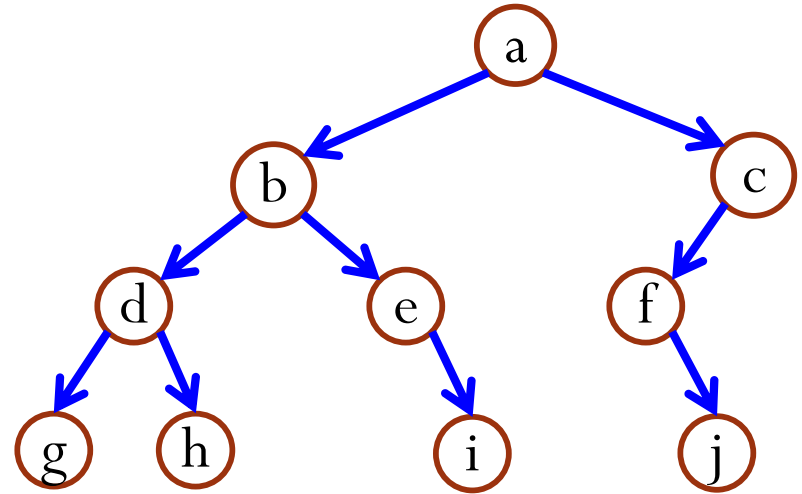


```
void inOrder(node *n) {  
    if(!n) return;  
    inOrder(n->left);  
    visit(n);  
    inOrder(n->right);  
}
```



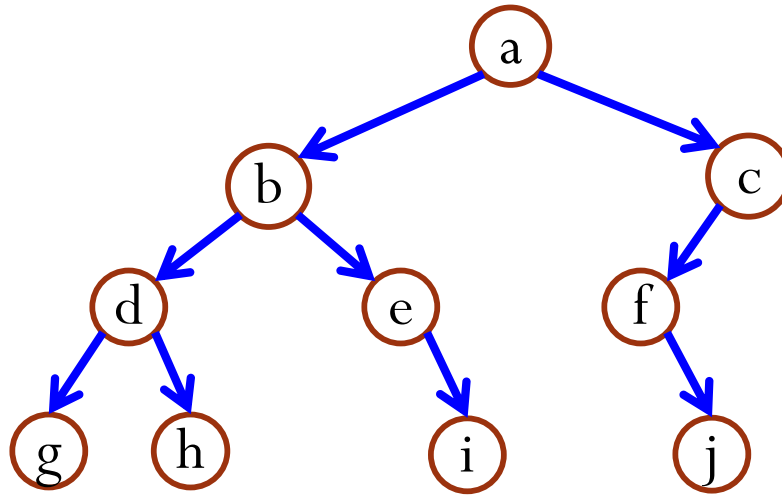
# ? What Is the Result of In-Order Depth-First Traversal?

- A. g, d, h, b, e, i, a, c, f, j
- B. g, d, h, b, e, i, a, f, j, c**
- C. g, d, h, b, i, e, a, j, f, c
- D. g, d, h, b, i, e, a, f, j, c



# Level-Order Traversal

- We want to traverse the tree level by level **from top to bottom**.
- Within each level, traverse **from left to right**.



How can we implement this traversal?

**a** → **b** → **c** → **d** → **e** → **f** → **g** → **h** → **i** → **j**

# Level-Order Traversal

## Procedure

- Use a queue!

1. Enqueue the root node into an empty queue.

2. While the queue is not empty, dequeue a node from the front of the queue.

1. Visit the node.

2. Enqueue its left child (if exists) and right child (if exists) into the queue.

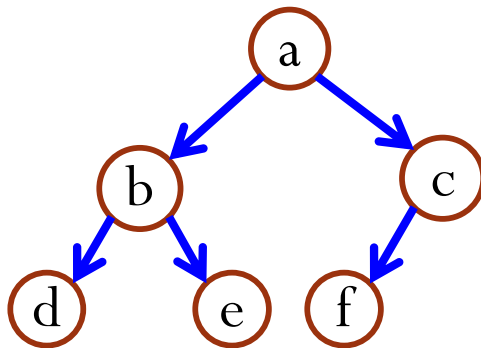
Loop



# Level-Order Traversal

## Code and Example

```
void levelOrder(node *root) {  
    queue q; // Empty queue  
    q.enqueue(root);  
    while(!q.isEmpty()) {  
        node *n = q.dequeue();  
        visit(n);  
        if(n->left) q.enqueue(n->left);  
        if(n->right) q.enqueue(n->right);  
    }  
}
```



Queue: 

a	b	c	d	e	f
---	---	---	---	---	---

Output:    a    b    c    d    e    f

# Binary Tree Traversal

## Application

- The expression  $a/b + (c - d)e$  has been encoded as a tree  $T$ .
  - The leaves are **operands**.
  - The internal nodes are **operators**.
- How would you traverse the tree  $T$  to print out the expression (ignoring parentheses)?
  - In-order depth-first traversal.
- What is the expression printed out by post-order depth-first traversal?
  - $ab/cd - e * +$
  - **Reverse Polish Notation**

