

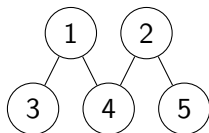
# Tree

Arnaud Malapert, Gilles Menez, Marie Pelleau

Master Informatique, Université Côte d'Azur

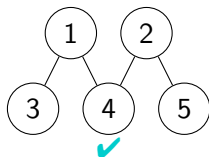
# Tree

In graph theory, a tree is an **undirected**, **acyclic**, **connected** graph



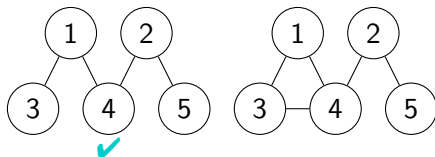
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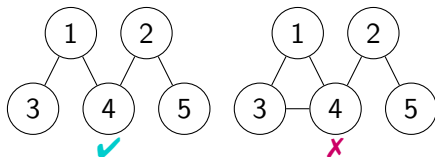
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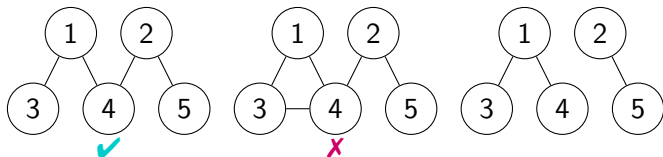
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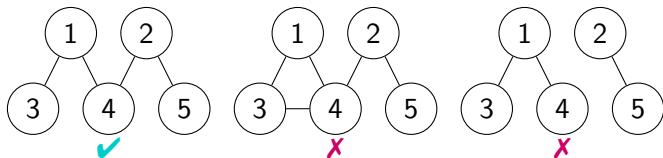
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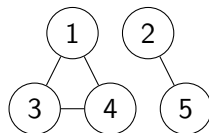
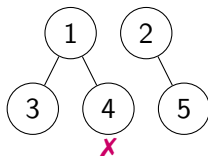
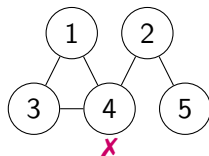
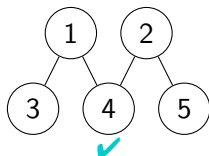
# Tree

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# Tree

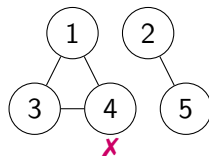
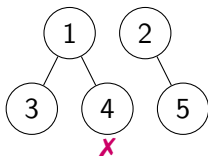
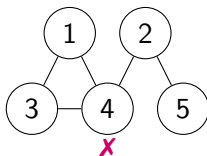
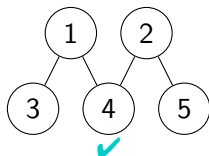
In graph theory, a tree is an **undirected**, **acyclic**, **connected** graph





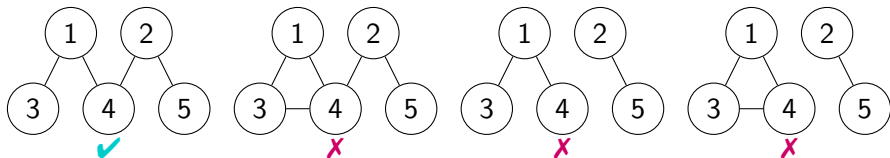
# Tree

In graph theory, a tree is an **undirected**, **acyclic**, **connected** graph



# Tree

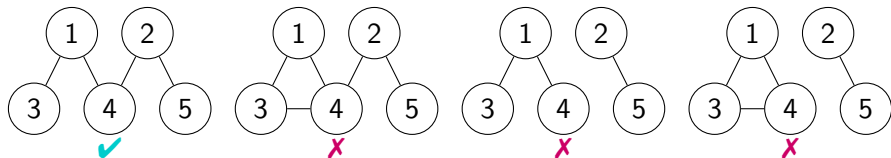
In graph theory, a tree is an **undirected**, **acyclic**, **connected** graph



Tree  $\implies n$  vertices,  $n - 1$  edges

# Tree

In graph theory, a tree is an **undirected**, **acyclic**, **connected** graph



Tree  $\implies n$  vertices,  $n - 1$  edges

## Search

- Breadth-first search
- Depth-first search
  - Pre-order
  - In-order
  - Post-order

# Depth-first search

For binary trees

Three steps:

- (L) Visit the left sub-tree
- (R) Visit the right sub-tree
- (N) Visit the node

# Depth-first search

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Pre-order( $v$ ) [NLR]

```
display v
Pre-order(left child of v)
Pre-order(right child of v)
```

# Depth-first search

For binary trees

Three steps:

- (L) Visit the left sub-tree
- (R) Visit the right sub-tree
- (N) Visit the node

In-order( $v$ ) [LNR]

```
In-order(left child of  $v$ )  
display  $v$   
In-order(right child of  $v$ )
```

# Depth-first search

For binary trees

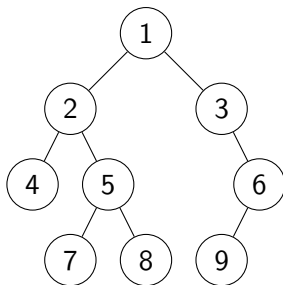
Three steps:

- (L) Visit the left sub-tree
- (R) Visit the right sub-tree
- (N) Visit the node

Post-order( $v$ ) [LRN]

```
Post-order(left child of  $v$ )  
Post-order(right child of  $v$ )  
display  $v$ 
```

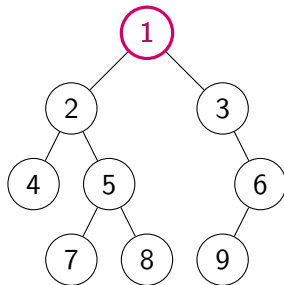
# Depth-first search



Pre-order

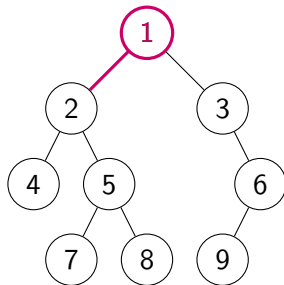


# Depth-first search



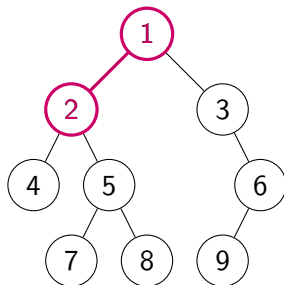
Pre-order 1

# Depth-first search



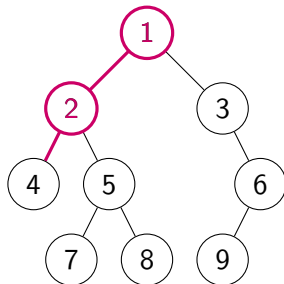
Pre-order 1

# Depth-first search



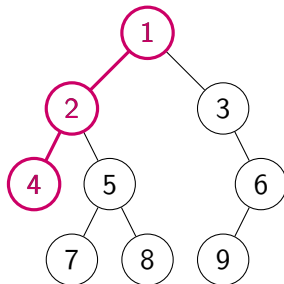
Pre-order 1 2

# Depth-first search



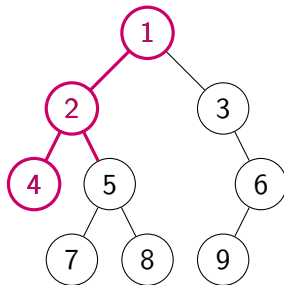
Pre-order 1 2

# Depth-first search



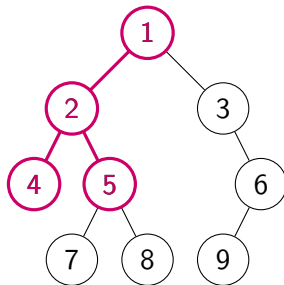
Pre-order 1 2 4

# Depth-first search



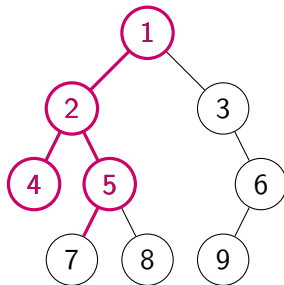
Pre-order 1 2 4

# Depth-first search



Pre-order 1 2 4 5

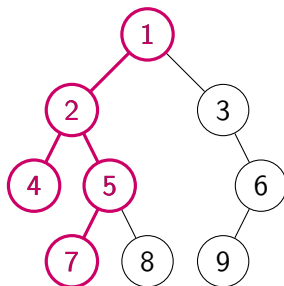
# Depth-first search



Pre-order 1 2 4 5

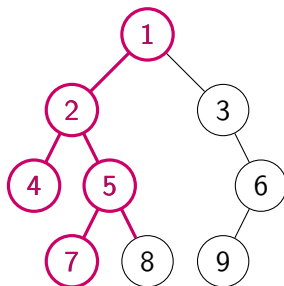


# Depth-first search



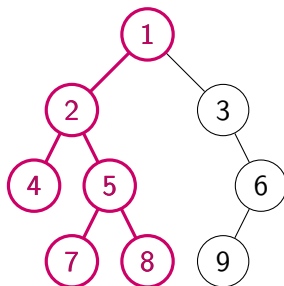
Pre-order 1 2 4 5 7

# Depth-first search



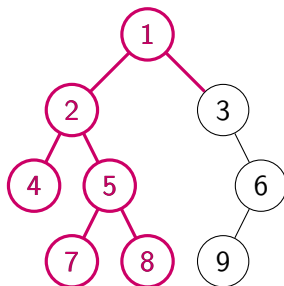
Pre-order 1 2 4 5 7

# Depth-first search



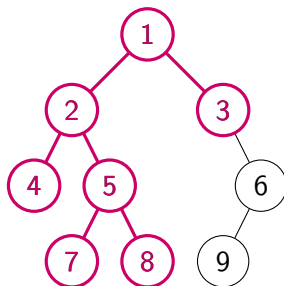
Pre-order 1 2 4 5 7 8

# Depth-first search



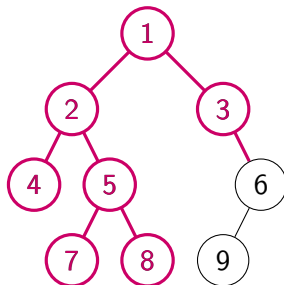
Pre-order 1 2 4 5 7 8

# Depth-first search



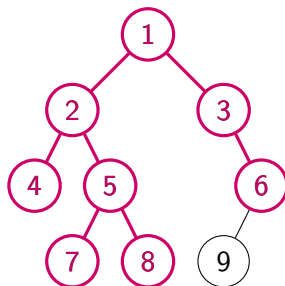
Pre-order 1 2 4 5 7 8 **3**

# Depth-first search



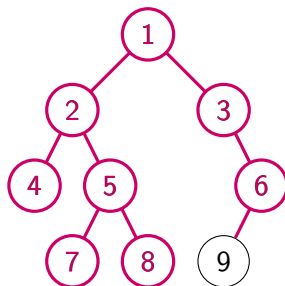
Pre-order 1 2 4 5 7 8 3

# Depth-first search



Pre-order 1 2 4 5 7 8 3 **6**

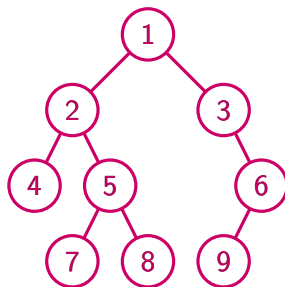
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6

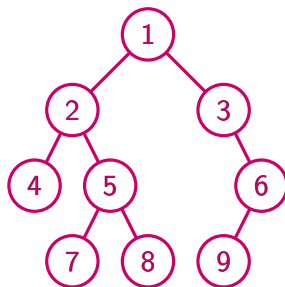


# Depth-first search



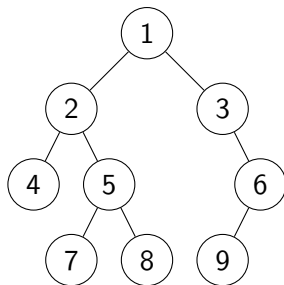
Pre-order 1 2 4 5 7 8 3 6 **9**

# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

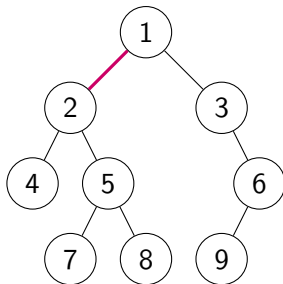
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order

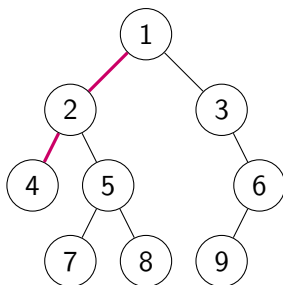
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order

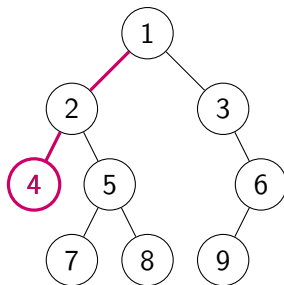
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order

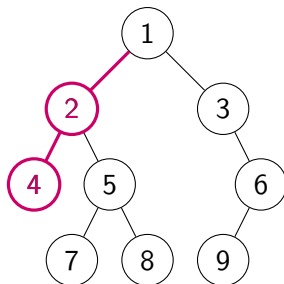
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order 4

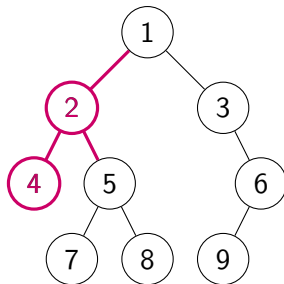
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2

# Depth-first search

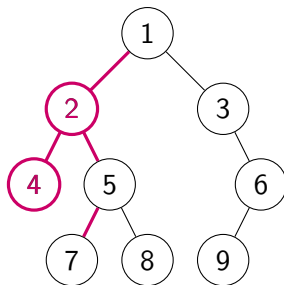


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2



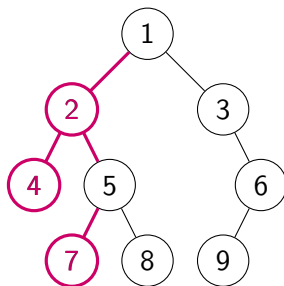
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2

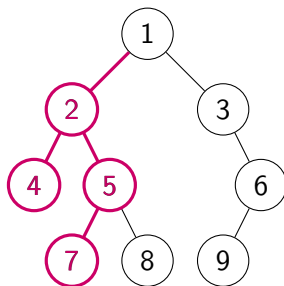
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7

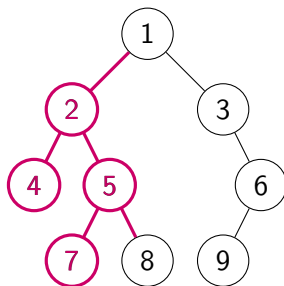
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 **5**

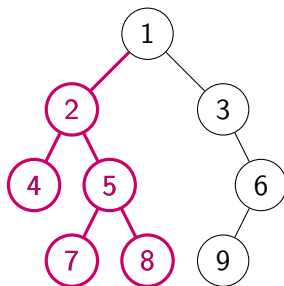
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5

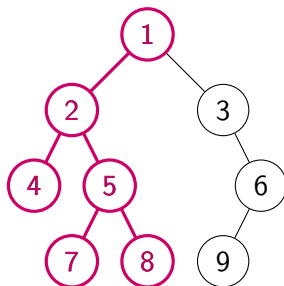
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 **8**

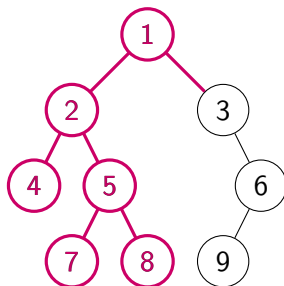
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 **1**

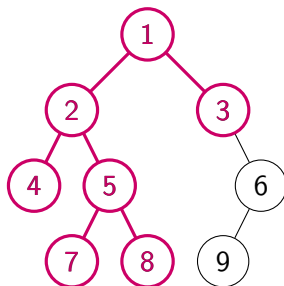
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1

# Depth-first search

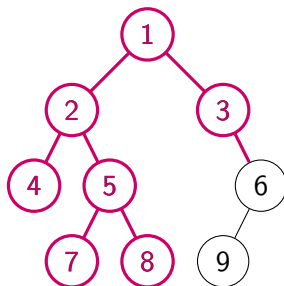


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 **3**



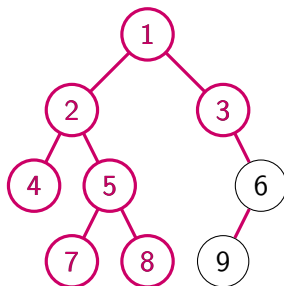
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3

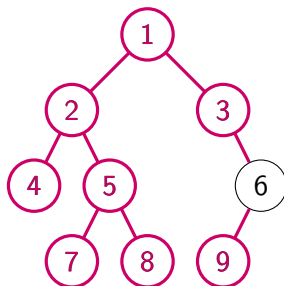
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3

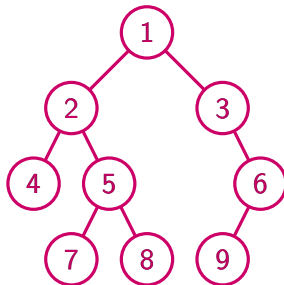
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 **9**

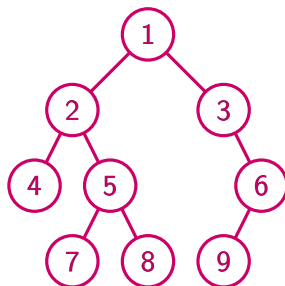
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 **6**

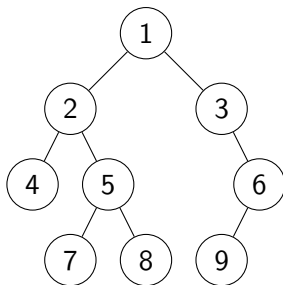
# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

# Depth-first search

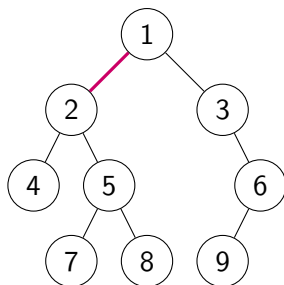


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order

# Depth-first search

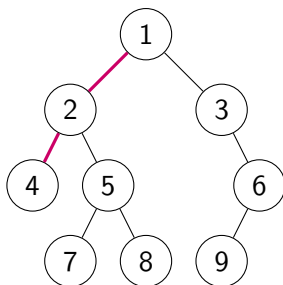


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order

# Depth-first search



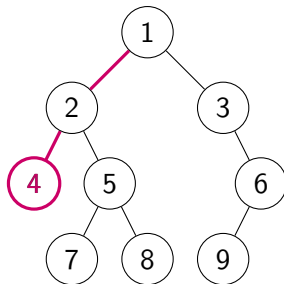
Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order



# Depth-first search

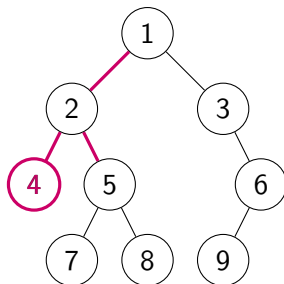


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order 4

# Depth-first search

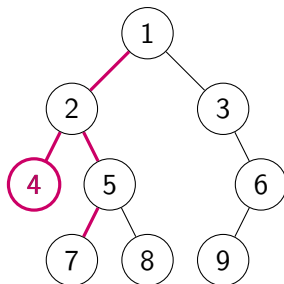


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order 4

# Depth-first search

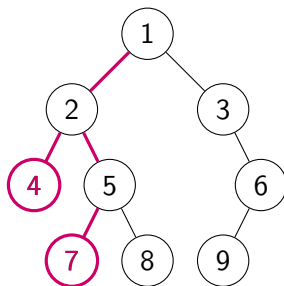


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order 4

# Depth-first search

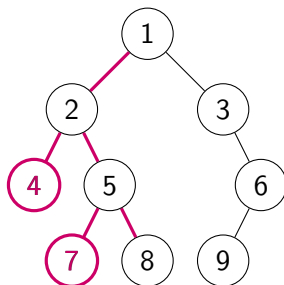


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order 4 7

# Depth-first search

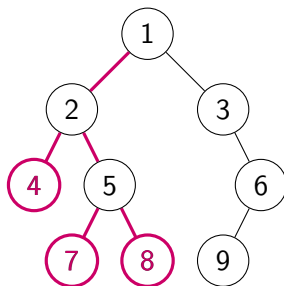


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order 4 7

# Depth-first search

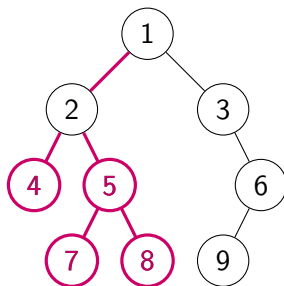


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order 4 7 8

# Depth-first search

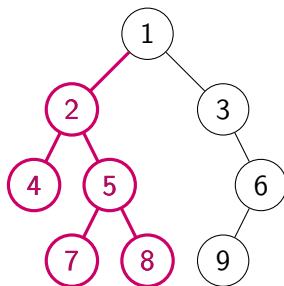


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order 4 7 8 **5**

# Depth-first search



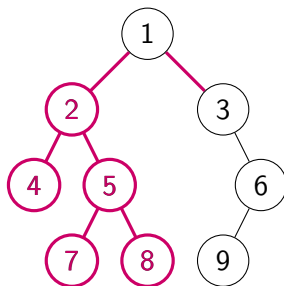
Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order 4 7 8 5 **2**



# Depth-first search

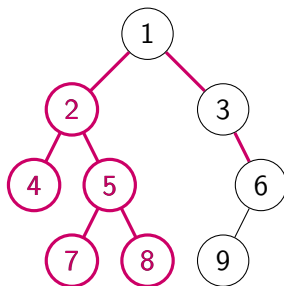


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order 4 7 8 5 2

# Depth-first search

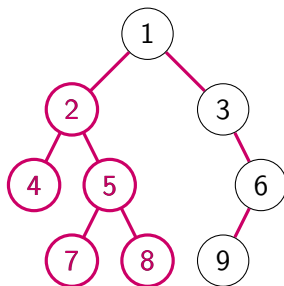


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order 4 7 8 5 2

# Depth-first search

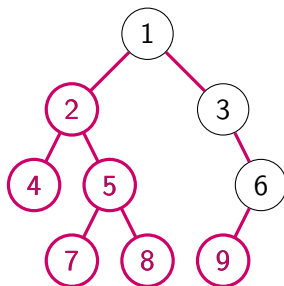


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order 4 7 8 5 2

# Depth-first search

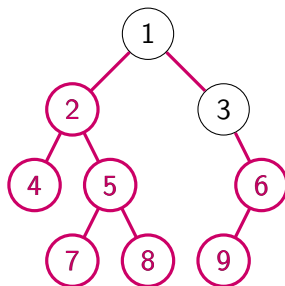


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order 4 7 8 5 2 **9**

# Depth-first search

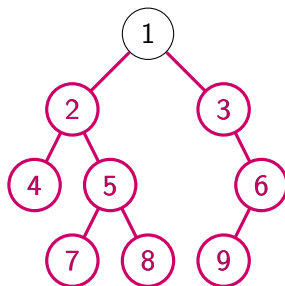


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order 4 7 8 5 2 9 **6**

# Depth-first search

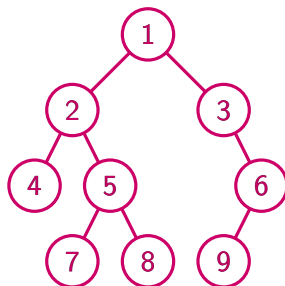


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order 4 7 8 5 2 9 6 **3**

# Depth-first search

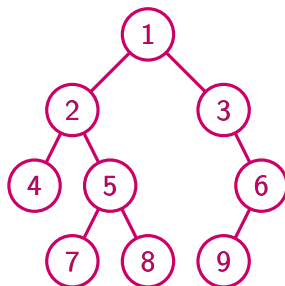


Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order 4 7 8 5 2 9 6 3 **1**

# Depth-first search



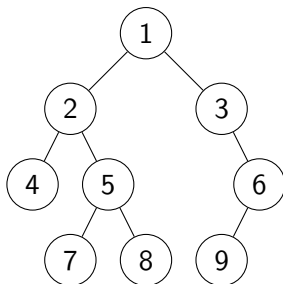
Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order 4 7 8 5 2 9 6 3 1



# Depth-first search



Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

Post-order 4 7 8 5 2 9 6 3 1

# Depth-first search

Given two traversals can a tree be retrieved?

# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order	1	2	4	5	7	8	3	6	9
In-order	4	2	7	5	8	1	3	9	6

# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

1

# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6



# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6



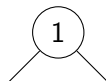


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Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

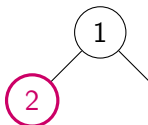


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

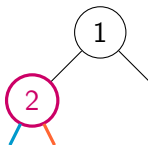


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Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

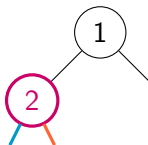


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

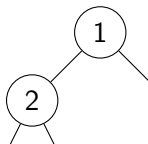


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

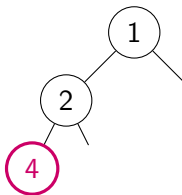


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

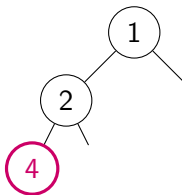


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

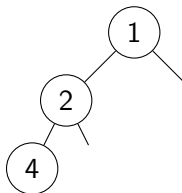


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6



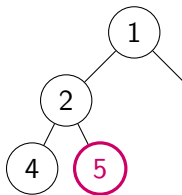


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

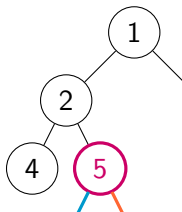


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Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

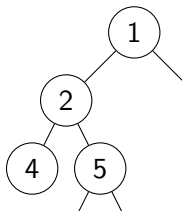


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Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

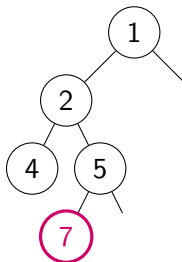


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Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

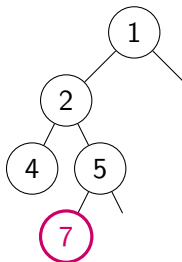


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

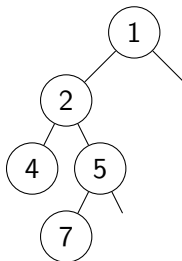


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

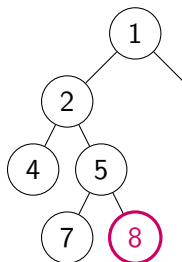


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

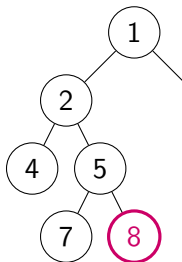


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 **8** 3 6 9  
In-order 4 2 7 5 **8** 1 3 9 6



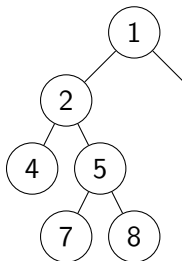


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Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

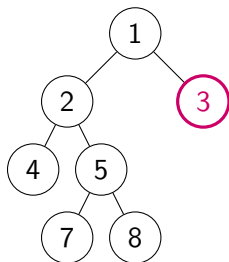


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Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

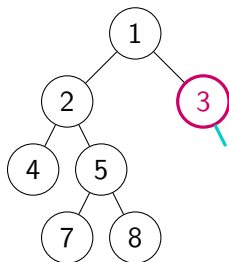


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- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

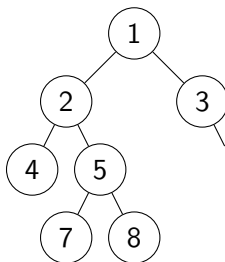


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Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

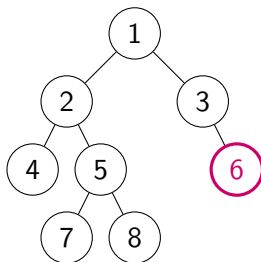


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Given two traversals can a tree be retrieved?

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Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

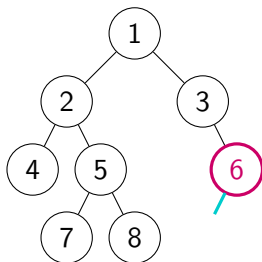


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Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

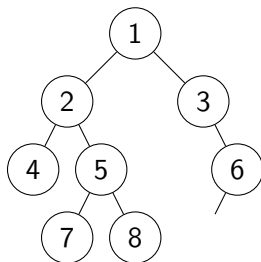


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Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6

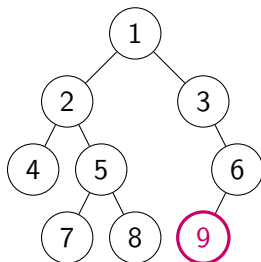


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Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6



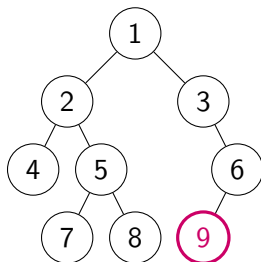


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 **9**  
In-order 4 2 7 5 8 1 3 **9** 6



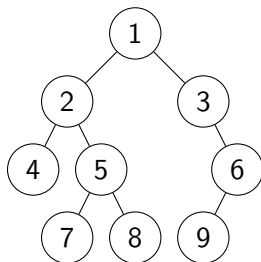
# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order

Pre-order 1 2 4 5 7 8 3 6 9

In-order 4 2 7 5 8 1 3 9 6

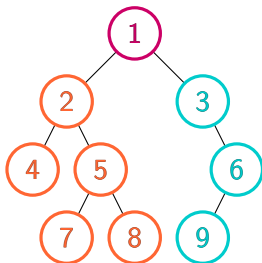


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓

Pre-order 1 2 4 5 7 8 3 6 9  
In-order 4 2 7 5 8 1 3 9 6



# Depth-first search

Given two traversals can a tree be retrieved?

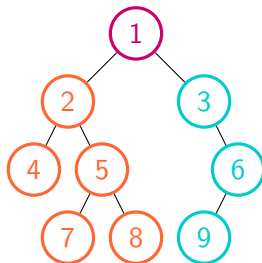
- Pre-order and In-order ✓
- Post-order and In-order

# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓

Post-order 4 7 8 5 2 9 6 3 **1**  
In-order 4 2 7 5 8 **1** 3 9 6



# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order	1	2	4	5	7	8	3	6	9
Post-order	4	7	8	5	2	9	6	3	1

# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1



# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1

# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1

1

# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1



# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1



# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1

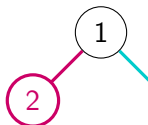


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Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
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Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1

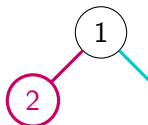


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Given two traversals can a tree be retrieved?

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Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1

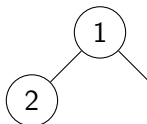


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1



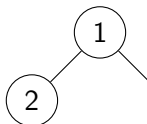


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Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
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- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
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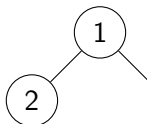


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1

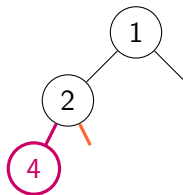


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1

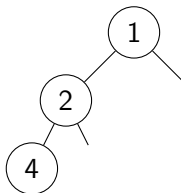


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1

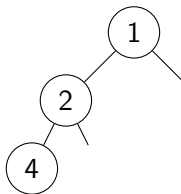


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1

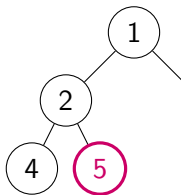


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Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1

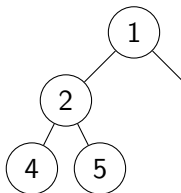


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- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1

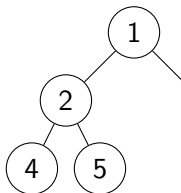


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Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1



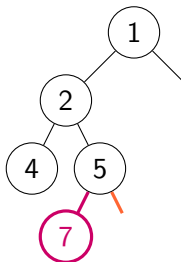


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Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1

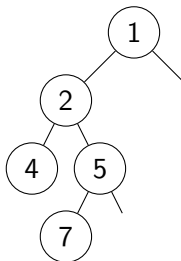


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1

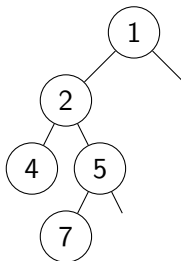


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Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1

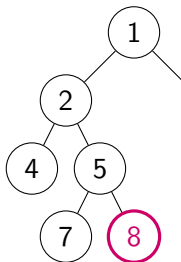


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1

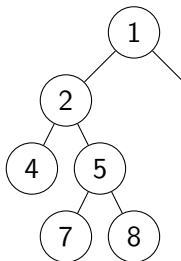


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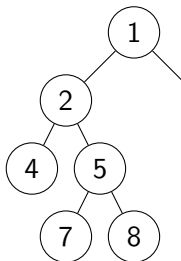


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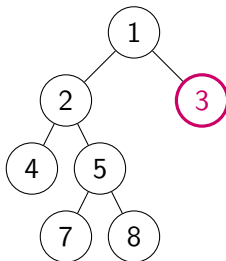


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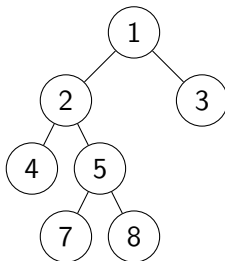


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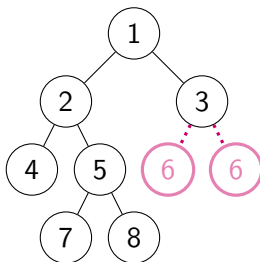


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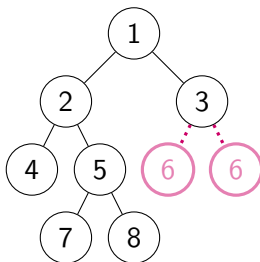


# Depth-first search

Given two traversals can a tree be retrieved?

- Pre-order and In-order ✓
- Post-order and In-order ✓
- Pre-order and Post-order ✗

Pre-order 1 2 4 5 7 8 3 6 9  
Post-order 4 7 8 5 2 9 6 3 1



## Exercise 1: Is it a tree

### Statement

Given  $N$  the number of nodes,  $M$  the number of edges and the list of edges, check if an unweighted, undirected graph is a tree

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### Example

Input:

3 2

1 2

2 3

Output:

YES

# Exercise 1: Is it a tree

## Statement

Given  $N$  the number of nodes,  $M$  the number of edges and the list of edges, check if an unweighted, undirected graph is a tree

## What problems can arise?

- What do we know of  $N$ ?

## Exercise 1: Is it a tree

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Given  $N$  the number of nodes,  $M$  the number of edges and the list of edges, check if an unweighted, undirected graph is a tree

### What problems can arise?

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- Of  $M$ ?

## Exercise 1: Is it a tree

### Solution 1: Build the graph

Build the graph with the list of edges

Check using BFS that all the nodes are visited once

## Exercise 1: Is it a tree

### Solution 1: Build the graph

Build the graph with the list of edges

Check using BFS that all the nodes are visited once

### Solution 2: Check on the list

if it can be a tree then

Maintain a visit array

Check that all the nodes are visited exactly once



## Exercise 1: Is it a tree

### More test cases

Input:

5 4  
1 3  
1 4  
4 2  
2 5

Output:

YES

Input:

5 5  
1 3  
1 4  
4 2  
2 5  
3 4

Output:

NO

Input:

5 3  
1 3  
1 4  
2 5

Output:

NO

Input:

5 4  
1 3  
1 4  
2 5  
3 4

Output:

NO

## Exercise 2: Tree order

### Statement

Given pre-order, post-order, and in-order traversals, determine if they can be of the same binary tree

## Exercise 2: Tree order

### Statement

Given pre-order, post-order, and in-order traversals, determine if they can be of the same binary tree

### Example

Input:

6

1 2 4 5 3 6

4 5 2 6 3 1

4 2 5 1 3 6

Output:

yes

## Exercise 2: Tree order

### Solution 1: Build the tree

Given two traversals build the tree

Generate the third traversal

Check that it matches the given one

## Exercise 2: Tree order

### Solution 1: Build the tree

Given two traversals build the tree

Generate the third traversal

Check that it matches the given one

### Solution 2: Check the orders

Check the three traversals all at once

## Exercise 2: Tree order

### More test cases

Input:

9

1 2 4 5 7 8 3 6 9

4 7 8 5 2 9 6 3 1

4 2 7 5 8 1 3 9 6

Output:

yes

Input:

9

1 2 4 5 7 8 3 6 9

4 7 5 8 2 9 6 3 1

4 2 7 5 8 1 3 9 6

Output:

no