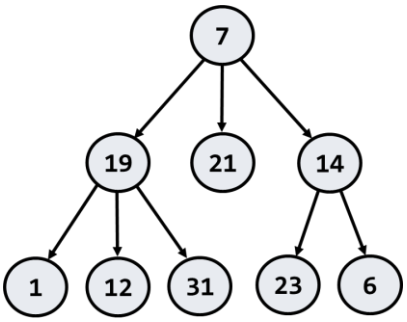
Homework: Basic Tree Data Structures

This document defines the **homework assignments** for the "Data Structures" course @ Software University.

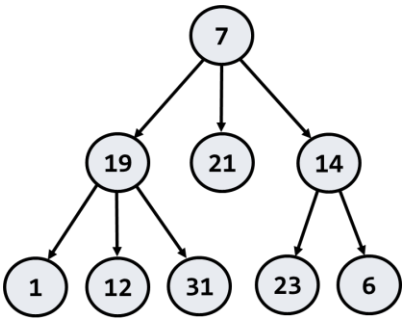
Problem 0. Introduction

You are given a **tree of N nodes** represented as a set of N-1 pairs of nodes (parent node, child node). Below are the operations that you are going implement.

Input	Comments	Tree	Definitions
9 7 19 7 21 7 14 19 1 19 12 19 31 14 23 14 6 27 43	N = 9 Nodes: 7→19, 7→21, 7→14, 19→1, 19→12, 19→31, 14→23, 14→6 P = 27 S = 43		Root node: 7 Leaf nodes: 1, 6, 12, 21, 23, 31 Middle nodes: 14, 19 Leftmost deepest node: 1 Longest path: 7 -> 19 -> 1 (length = 3) Paths of sum 27: 7 -> 19 -> 1 7 -> 14 -> 6 Subtrees of sum 43: 14 + 23 + 6

Problem 1. Root Node

Write a program to read the tree and find its **root** node:

Input	Output	Tree
9 7 19 7 21 7 14 19 1 19 12 19 31 14 23 14 6	Root node: 7	

Hints

Use the recursive **Tree<T>** definition. Keep the **value**, **parent** and **children** for each tree node:

```
public class Tree<T>
{
    public T Value { get; set; }
    public Tree<T> Parent { get; set; }
    public List<Tree<T>> Children { get; private set; }

    public Tree(T value, params Tree<T>[] children)...
}
```

Modify the **Tree<T> constructor** to **assign a parent** for each child node:

```
public Tree(T value, params Tree<T>[] children)
{
    this.Value = value;
    this.Children = new List<Tree<T>>();
    foreach (var child in children)
    {
        this.Children.Add(child);
        child.Parent = this;
    }
}
```

Use a **dictionary** to map nodes by their value. This will allow you to find the tree nodes during the tree construction (when you read the input data, you get the node values):

```
public class Program
{
    static Dictionary<int, Tree<int>> nodeByValue = new Dictionary<int, Tree<int>>();

    static void Main()
    {
        // Problem solution
    }
}
```

Write a method to **find the tree node by its value or create a new node** if it does not exist:

```
static Tree<int> GetTreeNodeByValue(int value)
{
    if (!nodeByValue.ContainsKey(value))
    {
        nodeByValue[value] = new Tree<int>(value);
    }

    return nodeByValue[value];
}
```

Create a method for adding an edge to the tree

```
public void AddEdge(int parent, int child)
{
    Tree<int> parentNode = GetTreeNodeByValue(parent);
    Tree<int> childNode = GetTreeNodeByValue(child);

    parentNode.Children.Add(childNode);
    childNode.Parent = parentNode;
}
```

Now you are ready to **create the tree**. You are given the **tree edges** (parent + child). Use the dictionary to lookup the parent and child nodes by their values:

```
static void ReadTree()
{
    int nodeCount = int.Parse(Console.ReadLine());
    for (int i = 1; i < nodeCount; i++)
    {
        string[] edge = Console.ReadLine().Split(' ');
        AddEdge(int.Parse(edge[0]), int.Parse(edge[1]));
    }
}
```

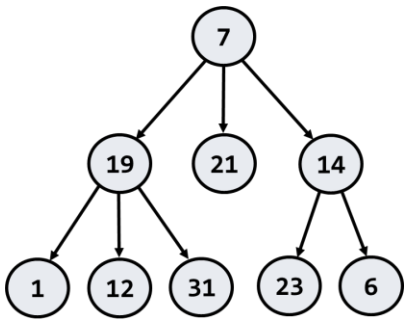
Finally, you can find the root (the node that has no parent)

```
static Tree<int> GetRootNode()
{
    return nodeByValue.Values
        .FirstOrDefault(x => x.Parent == null);
}
```

Problem 2. Print Tree

Write a program to read the tree from the console and print it in the following format (each level indented +2 spaces):

Input	Output	Tree

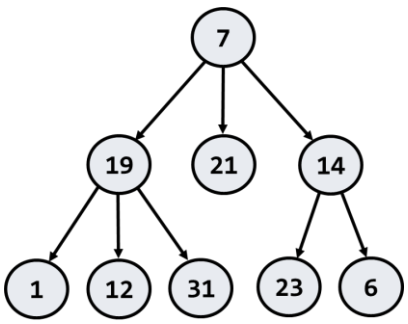
9
7 19
7 21
7 14
19 1
19 12
19 31
14 23
14 6
	7
	  19
	  1
	  12
	  31
	  21
	  14
	  23
	  6
		

Hints

Find the root and recursively print the tree

Problem 3. Leaf Nodes

Write a program to read the tree and find all **leaf** nodes (in increasing order):

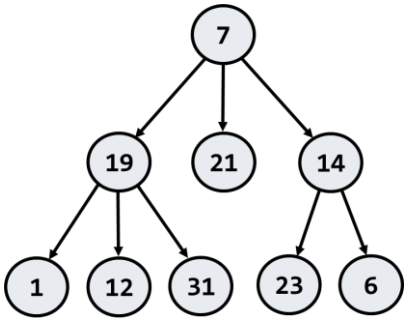
Input	Output	Tree
9 7 19 7 21 7 14 19 1 19 12 19 31 14 23 14 6	Leaf nodes: 1 6 12 21 23 31	

Hints

Find the all nodes that have no children

Problem 4. Middle Nodes

Write a program to read the tree and find all **middle** nodes (in increasing order):

Input	Output	Tree
9 7 19 7 21 7 14 19 1 19 12 19 31 14 23 14 6	Middle nodes: 14 19	

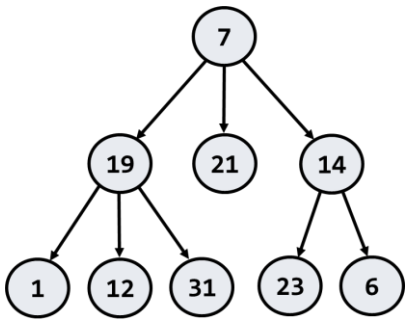
Hints

```
static void PrintMiddleNodes()
{
    var nodes = nodeByValue.Values
        .Where(x => x.Parent != null && x.Children.Count != 0)
        .Select(x => x.Value)
        .OrderBy(x => x)
        .ToList();

    Console.WriteLine("Middle nodes: " + string.Join(" ", nodes));
}
```

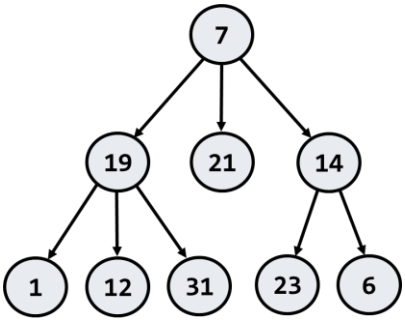
Problem 5. * Deepest Node

Write a program to read the tree and find its deepest node (leftmost):

Input	Output	Tree
9 7 19 7 21 7 14 19 1 19 12 19 31 14 23 14 6	Deepest node: 1	

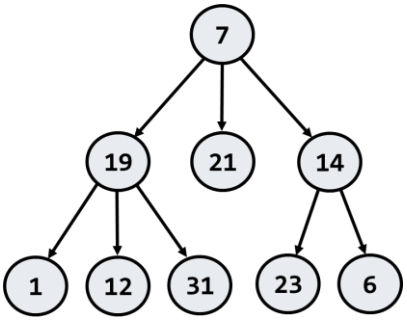
Problem 6. Longest Path

Find the **longest path** in the tree (the leftmost if several paths have the same longest length)

Input	Output	Tree
9 7 19 7 21 7 14 19 1 19 12 19 31 14 23 14 6	Longest path: 7 19 1	

Problem 7. All Paths With a Given Sum

Find all paths in the tree with **given sum** of their nodes (from the leftmost to the rightmost)

Input	Output	Tree
9 7 19 7 21 7 14 19 1 19 12 19 31 14 23 14 6 27	Paths of sum 27: 7 19 1 7 14 6	

Problem 8. * All Subtrees With a Given Sum

Find all **subtrees with given sum** of their nodes (from the leftmost to the rightmost). Print subtrees in **pre-order** sequence

Input	Output	Tree
9 7 19 7 21 7 14 19 1 19 12 19 31 14 23 14 6 43	Subtrees of sum 43: 14 23 6