

# Question 1

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Please indicate if each statement is `true` or `false` by returning the appropriate `boolean` from the corresponding method in the `BinaryWarmUp` class!

For example, the following means the first statement is false.

```
public static boolean s1() {  
    return false;  
}
```

## Statements

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1. Circular array enables efficient implementation (amortized constant time) of all operations for Queue.
2. Implementing a doubly linked list without sentinel nodes results in much simpler methods and fewer special (edge) cases.
3. A pre-order traversal of a binary tree always visits the subtree before it processes the data in the root of that subtree.
4. A Set is a collection of unique elements, but the elements might not be Comparable.
5. The height of a node in a tree is defined as the length of the shortest path from the root of the tree to that node.

# Question 2

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Please indicate the correct choice by returning the appropriate `char []` array from the corresponding method in the `ToughChoices` class!

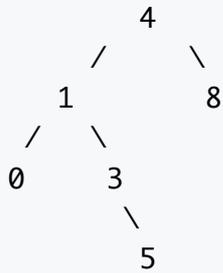
For example, the following means the answer to the first MCQ is `a` and `c`, whereas the answer to the second question is `b`.

```
public static char q1() {  
    return new char[] {'a', 'c'};  
}  
  
public static char q2() {  
    return new char[] {'b'};  
}
```

## Multiple-Choice Questions

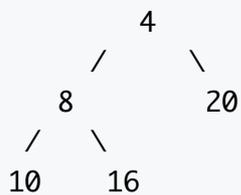
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1. How efficiently can we do an `insertBack()` operation on a List containing  $N$  items if it is implemented as a singly linked list that has both a `head` and a `tail` reference?
  - a.  $O(1)$
  - b.  $O(\lg N)$
  - c.  $O(N)$
  - d. It cannot be done in a singly linked list
2. Suppose you are implementing a *minimum* priority queue with a tree-based heap. In which type of node will a unique largest priority be stored?
  - a. root only
  - b. External nodes (leaves)
  - c. Internal nodes (those other than the root or leaves)
  - d. It could be stored anywhere
3. The \_\_\_\_\_ cost of an operation is calculated by summing the total cost of some number of operations and then dividing by that number of operations.
  - a. amortized
  - b. best case
  - c. worst case
  - d. expected
4. This is supposed to be an AVL tree. Which AVL tree properties, if any, are violated in this example?



- a. no violations
- b. order only
- c. balance only
- d. order and balance both

5. Given this heap based minimum priority queue, what would its ranked array representation be after a remove operation?



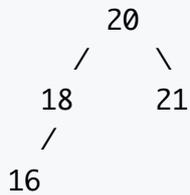
- a.  $[-, 4, 8, 20, 10]$
- b.  $[-, 8, 16, 20, 10]$
- c.  $[-, 8, 10, 20, 16]$
- d.  $[-, 16, 8, 20, 10]$

6. What is the height of a binary heap with  $2^N$  elements?

- a.  $2^N$
- b.  $N$
- c.  $N^2$
- d.  $\log N$

## Question 3

Consider the following AVL Tree:



And, assume we have a `toString` method which displays this tree as

```
[20, 18, 21, 16, null, null, null, null, null]
```

What does `toString` method return after `insert(17)` ?

Write your answer in the `ShortAnswer.md` file and justify it by showing the AVL Tree states through the insertion process.

Feel free to check out the implementation of `BinaryTree.toString` method.

## Question 4

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Complete the implementation of `PriorityQueue.swim` based on the provided code, comments therein, and your general understanding of the "swim" process.

## Question 5

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Complete the implementation of `BinarySearchTree.isValid` based on the provided code, comments therein, and your general understanding of the binary search tree properties.

### Hints:

1. The input is (for sure) a binary tree
2. The order property in BST states "all" values to the left of a node are smaller than the value stored in it (not just the left child). Likewise, all values to the right of a node are larger than the value stored in it (not just the right child).