

CS 61B Homework 7  
Due 5pm Wednesday, April 8, 2009

This homework will give you practice with 2-3-4 trees. This is an individual assignment; you may not share code with other students.

Copy the Homework 7 directory by doing the following, starting from your home directory.

```
cp -r $master/hw/hw7 .
```

Your task is to implement the insertion operation of a 2-3-4 tree, in the file `Tree234.java` (in the `dict` package). For simplicity, the tree stores only keys; no element is associated with each key. Furthermore, the keys are ints.

The central two operations have the following prototypes.

```
public boolean find(int key);  
public void insert(int key);
```

`find()` returns true if the specified key is in the tree, and false otherwise. `find()` is already implemented for you; inspecting the code will help you understand the data structure better. `insert()` inserts its parameter "key" into the tree. Please implement the top-down insertion algorithm described in the Lecture 27 notes, and not the bottom-up insertion algorithm described by Goodrich and Tamassia.

Because there is no object associated with each key, there is no reason to store duplicate keys. Hence, if a key is found to already be in the tree, don't insert another copy.

A `toString()` method is also provided for 2-3-4 trees, and is useful for testing. Do not change it; the autograder will use it to check your trees.

There's also a `printTree()` method, which prints a 2-3-4 tree in an easier-to-read, but more space-consuming, tree-shaped manner (albeit sideways). This method will not be tested, and you may change it to your liking.

The `Tree234Node` class represents a node in a 2-3-4 tree, and has the following fields.

```
int keys;  
int key1;  
int key2;  
int key3;  
Tree234Node parent;  
Tree234Node child1;  
Tree234Node child2;  
Tree234Node child3;  
Tree234Node child4;
```

The "keys" field is the number of keys stored in the node, and must be 1, 2, or 3. The fields "key1", "key2", and "key3" are filled in (in order) with the int keys stored in the node. If `keys == 1`, the value of `key2` doesn't matter. If `keys < 3`, the value of `key3` doesn't matter.

The "parent" field is the node's parent. The fields "child1" through "child4" are the node's children, and are filled in in order from `child1` to `child4`. All four of these references must be set to null in a leaf node. If `keys == 1`, `child3` should be null, and if `keys < 3`, the value of `child4` should be null.

You may not change any of these constraints on how a `Tree234Node` is represented, but you may add fields and helper methods to the `Tree234` and `Tree234Node` classes if it helps. However, make sure that the `toString()` methods and the `find()` method work correctly in their unmodified forms.

Do not change `toString()` or `find()`.

Test code is provided in the main method of the `Tree234` class. To compile, change (cd) to your `hw7` directory and type `"javac -g dict/*.java"`. To run, type `"java dict.Tree234"`. The test code does not test whether you correctly update the tree's "size" field; you'll have to test that yourself.

Submitting your solution

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Change (cd) to your `hw7` directory, which should contain the `dict` directory. The `dict` directory should contain `Tree234.java` and `Tree234Node.java`. You're not allowed to change `IntDictionary.java`, so you can't submit it. Make sure your homework compiles and runs on the `_lab_` machines just before you submit.

From your `hw7` directory, type `"submit hw7"`. (Note that "submit" will not work if you are inside the `dict` directory!) After submitting, if you realize your solution is flawed, you may fix it and submit again. You may submit as often as you like. Only the last version you submit before the deadline will be graded.