# CS61B Fall 2015 Guerrilla Section 2 Worksheet 

31 October 2015

Directions: In groups of $4-5$, work on the following exercises. Do not proceed to the next exercise until everyone in your group has the answer and understands why the answer is what it is. Of course, a topic appearing on this worksheet does not imply that the topic will appear on the midterm, nor does a topic not appearing on this worksheet imply that the topic will not appear on the midterm.

## 1 Hashing Mechanics

Insert the following words into a hash table (in the same order that they are listed): galumphing, frumious, slithy, borogroves, mome, bandersnatch. Assume that the hash code of a String is just its length (note that this is not actually the hash code for Strings in Java). Use external chaining to resolve collisions, use 4 as the initial size of the array and double the size when the load factor is equal to 1.

## 2 More Hashing

Describe a potential problem with each of the following:
(a) An implementation of the hashCode method of the String class that simply returns the length of the string (i.e. the hash code used in problem 1).
(b) An implementation of the hashCode method of the String class that simply returns a random number each time.
(c) Overriding the equals method of a class without overriding the hashCode method.
(d) Overriding the hashCode method of a class without overriding the equals method.
(e) Modifying an object after inserting it into a HashSet.

## 3 Using Hash Tables

Given an array $A$ of integers and an integer $x$ we want to find out if $A$ contains two integers $y$ and $z$ such that $y+z=x$. Write a function that accomplishes this efficiently in most cases (the worst case running time is allowed to be slow). For a hint, look at the title of this question.


```
```

public static boolean twoSum(int[] A, int x) {

```
```

```
```

public static boolean twoSum(int[] A, int x) {

```
```


$\qquad$

$\qquad$
,
10

## 4 Heap Mechanics

Fill in the following class to implement the insert method for a min heap. Assume that the heap is implemented with an array where the root is stored at index 1 (rather than index 0 ). You do not need to handle resizing the array.

```
public class MinHeap {
    /** Initializes an empty min heap. */
    public MinHeap() {
        //Implementation not shown.
    }
    /** Removes and returns the minimum element stored in this heap. */
    public int removeMin() {
    //Implementation not shown.
    }
    /** Returns the minimum integer stored in this heap. */
    public int findMin() {
        return data[1];
    }
    /** Inserts the integer X into this heap. */
    public void insert(int x) {
    }
    //You may add other instance methods here.
    /** The data used to represent this heap. */
private int[] data;
/** The number of elements currently being stored in this heap. */
private int size;
}
```

DON'T PROCEED UNTIL EVERYONE IN YOUR GROUP HAS FINISHED AND UNDERSTANDS ALL EXERCISES IN THIS SECTION!

## 5 Lowest Common Ancestor (CS61B Fall 2013 Midterm 2)

The lowest common ancestor of two nodes in a tree is the deepest node in the tree (furthest from the root) that has both of the nodes as descendants. It can be one of the two nodes (if one is an ancestor of the other). Write a function that takes the root of a binary search tree along with two integers that are in that tree and returns the lowest common ancestor of those two integers.

```
public class TreeNode {
    public int val;
    public TreeNode left;
    public TreeNode right;
    /** Assuming that }T\mathrm{ is a binary search tree and that KEYI and
        * KEY2 both appear in T, returns the value of the lowest common
        * ancestor of the nodes containing KEY1 and KEY2. */
    public static int findLCA(TreeNode T, int key1, int key2) {
    }
}
```


## 6 Game Trees

Consider the game tree shown below. Trapezoids that 'point' up, represent the player seeking to maximize the heuristic evaluation (this is you); trapezoids that 'point' down represent the player seeking to minimize the heuristic evaluation (your opponent).

(a) Fill out the values in the 'maximizer' and 'minimizer' node for the above game tree after applying the minimax algorithm to it.
(b) Cross out (with an X) all branches that would be pruned by a Minimax implementation that utilizes the pruning strategy discussed in class at the end of lecture $\# 22$ (alpha-beta pruning).
(c) According to the minimax algorithm, which move should we make for the above game? Say, your opponent was a 3-year old, would you still use the minimax algorithm?

## 7 Generics and Binary Trees

(a) Suppose that we have a binary tree where the nodes contain objects that can be compared to each other. Then we could define an order on such trees in the following way: a tree $T_{1}$ is considered greater than a tree $T_{2}$ if one of the following holds:

- $T_{2}$ is empty and $T_{1}$ is not.
- The value in the root of $T_{1}$ is greater than the value in the root of $T_{2}$.
- The values in the roots are equal and the left subtree of $T_{1}$ is greater than the right subtree of $T_{2}$.
- The values in the roots are equal and the left subtrees are equal and the right subtree of $T_{1}$ is greater than the right subtree of $T_{2}$.

Fill in the class ComparableTree below so that the compareTo method will give the ordering described above. You may assume that the values stored in the tree are never null.

```
public class ComparableTree<_-_----------------------------------
    implements _------------------------------------ {
    public T val;
    public ComparableTree<T> left;
    public ComparableTree<T> right;
    @Override
    public int compareTo(_------------------------) {
    }
}
```

(b) What type of tree traversal does the above ordering correspond to?

## 8 Assorted Heap Questions

(a) Describe a way to modify the usual max heap implementation so that finding the minimum element takes constant time without incurring more than a constant amount of additional time and space for the other operations.
(b) (Fall 2014 Final exam) In class, we looked at one way of implementing a priority queue: the binary heap. Recall that a binary heap is a nearly complete binary tree such that any node is smaller than all of its children. There is a natural generalization of this idea called a $d$-ary heap. This is also a nearly complete tree where every node is smaller than all of its children. But instead of every node having two children, every node has $d$ children for some fixed constant $d$.

1. Describe how to insert a new element into a d-ary heap (this should be very similar to the binary heap case). What is the running time in terms of $d$ and $n$ (the number of elements)?
2. What is the running time of finding the minimum element in a $d$-ary heap with $n$ nodes in terms of $d$ and $n$ ?
3. Describe how to remove the minimum element from a $d$-ary heap (this should be very similar to the binary heap case). What is the running time in terms of $d$ and $n$ ?
