CS 61B Spring 2020 — Exam Prep 10: Hashing and Heaps

1 Hashing Gone Crazy

For this question, use the following TA class for reference -

```
public class TA {
    int charisma;
    String name;
    TA(String name, int charisma) {
        this.name = name;
        this.charisma = charisma;
    }
    @Override
    public boolean equals(Object o) {
        TA other = (TA) o;
        return other.name.charAt(0) == this.name.charAt(0);
    }
    @Override
    public int hashCode() {
        return charisma;
    }
}
```

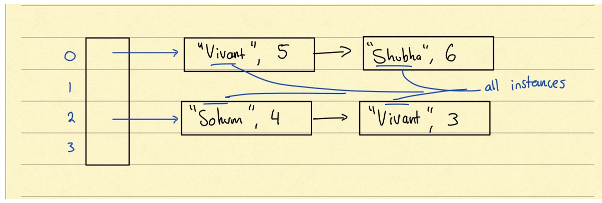
Assume that the hashCode of a TA object returns charisma, and the equals method returns true if and only if two TA objects have the same first letter in their name.

Draw the contents of map after the executing the insertions below:

```
ECHashMap<TA, Integer> map = new ECHashMap<>();
TA sohum = new TA("Sohum", 10);
TA vivant = new TA("Vivant", 20);
map.put(sohum, 1);
map.put(vivant, 2);

vivant.charisma += 2;
map.put(vivant, 3);

sohum.name = "Vohum";
map.put(vivant, 4);

sohum.charisma += 2;
map.put(sohum, 5);

sohum.name = "Sohum";

TA shubha = new TA("Shubha", 24);
map.put(shubha, 6);
```

Assume that the ECHashMap is a HashMap implemented with external chaining as depicted in lecture. The ECHashMap instance begins at size 4 and, for simplicity, does not resize.

Solution:



2 Buggy Hash

The following classes may contain a bug in one of its methods. Identify those errors and briefly explain why they are incorrect and in which situations would the bug cause problems.

(a)
```java
class Timezone {
    String timeZone; // "PST", "EST" etc.
    boolean dayLight;
    String location;
    ...
    public  int currentTime() {
        // return the current time in that time zone
    }
    public int hashCode() {
        return currentTime();
    }
    public boolean equals(Object o) {
        Timezone tz = (Timezone) o;
        return tz.timeZone.equals(timeZone);
    }
}
```

Although equal objects will have the same hashcode, but the problem here is that `hashCode()` is not deterministic. This will result in weird behaviors (e.g. the element getting lost) when we try to put or access elements in our hashing data structures.

(b)
```java
class Course {
    int courseCode;
    int yearOffered;
    String[] staff;
    ...
    public int hashCode() {
        return yearOffered + courseCode;
    }
    public boolean equals(Object o) {
        Course c = (Course) o;
        return c.courseCode == courseCode;
    }
}
```

The problem with this `hashCode()` is that not all equal objects have the same hashcode. One key thing to remember is that when we override the `equals()` method, we have to also override the `hashCode()` method to ensure equal objects have the same hashcode.

3 Semi Sorted Heaps

Given a heap represented as an array, determine if it is a valid min-heap and semi-sorted.

For a min-heap to be semi-sorted, all the elements in the left branch must be smaller than the elements in the right branch. The first element of the min-heap is at index 1, and you can assume the array has length of at least 4 for simplicity.

For e.g. if array A = [*, 1, 2, 6, 5, 4, 9, 8] represents a heap, the method should return true, since 2, 5, 4 in left branch are all less than 6, 9, 8 in right branch.

```java
public static boolean isSemiSortedHeap(int[] arr) {
    int rightTop = arr[3];

    for (int row = 2; row < arr.length; row *= 2) {
        for (int col = row; col < Math.min(row * 2, arr.length); col++) {
            // If it doesn't satisy minheap property
            boolean a = arr[col/2] > arr[col];

            // If it is on the left side and it is not less than the right
               minimum
            boolean b = (col < (row/2)*3) && (arr[col] > rightTop);

            if (a || b) {
                return false;
            }
        }
    }
    return true;
}
```

4 Min Heaps

Fill in the following blanks related to min-heap -

(a) `removeMin` has a best case runtime of $\Theta(1)$ and a worst case runtime of $\Theta(logN)$.

(b) `insert` has a best case runtime of $\Theta(1)$ and a worst case runtime of $\Theta(logN)$.

(c) A pre order or level order traversal on a min-heap can output the elements in sorted order.

(d) The fourth smallest element in a min-heap with 1000 distinct elements can appear in 14 places in the heap. (it can be on the second, third, or fourth levels)

(e) Given a min-heap with $2^n - 1$ distinct elements, for an element -

- to be on the second level it must be less than $2^{(n-1)} - 2$ element(s) and greater than 1 element(s). (must be greater than the topmost and less than the elements in its subtree)
- to be on the bottommost level it must be less than 0 element(s) and greater than n-1 element(s). (must be greater than the elements on its branch)