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CS 455 Midterm 2

Fall 2017 [Bono]

Nov. 7, 2017

There are 6 problems on the exam, with 62 points total available. There are 10 pages to the exam (5 pages double-sided), including this one; make sure you have all of them. There is also a one-page code handout that accompanies the exam. If you need additional space to write any answers or for scratch work, pages 8, 9, and 10 of the exam are left blank for that purpose. If you use these pages for answers you just need to direct us to look there. ***Do not detach any pages from this exam.***

Note: if you give multiple answers for a problem, we will only grade the first one. Avoid this issue by labeling and **circling** your final answers and crossing out any other answers you changed your mind about (though it's fine if you show your work).

Put your name and USC username (a.k.a., NetID) at the top of the exam. Also, put your NetID at the top right of the front side of *every* page of the exam. Please read over the whole test before beginning. Good luck!

Problem 1 [3 pts]

Consider the following array of integers (array index shown above corresponding array value):

0	1	2	3	4	5	6
15	7	6	12	5	4	9

Show the contents of the same array after the first three passes of insertion sort (sorting into increasing order). Show each value under its array index. Hint: For an n-element array, it's completely sorted after n-1 passes.

0	1	2	3	4	5	6
6	7	12	15	5	4	9

1st Pass

7 15 6 12 5 4 9

2nd Pass

6 7 15 12 5 4 9

3rd

6 7 12 15 5 4 9

Problem 2 [3 points]

Recall that the method `entrySet` that's part of the `Map` interface returns a `Set` view of the `Map` whose elements are type `Map.Entry<KeyType, ValueType>`. All the `Map.Entry` methods are shown below:

<code>KeyType getKey()</code>	Return the key of the entry
<code>ValueType getValue()</code>	Return the value of the entry
<code>void setValue(newValue)</code>	Replace the current value with <code>newValue</code>

Why is there no `setKey` method for `Map.Entry`? (limit your answer to one or two sentences – we will not read beyond that)

If we `setKey` for `Map.Entry`, for example, "Jane" → "Joe"

Then when we add or search for "Joe", we will get another object.

That is, same key like "Joe", we will have different `hashCode`.

Problem 3 [8 pts.]

Implement the boolean method `sortDecreasingByScore`, which sorts an ArrayList of `Student`'s so they are in decreasing order by score. For students with the same score, they must be in increasing order by name. *You must use the Java sort utility* (more info about that on the code handout), and include any additional code necessary to make it work (outside of the `sortByScore` method). Note: your answer must be written using Java 7 features (e.g., no lambda expressions).

Here is an example of contents of such an `ArrayList` shown in the order it would be in after a call to `sortDecreasingByScore`:

Jan 98
Lin 98
Ann 84
Fred 84
Moe 84
Zhou 80
Aarti 72

alphanumeric

Here is the `Student` class it uses (only shows interface, since that's all we are using here). This is an already completed class; *you may not modify the Student class for this problem*.

```
public class Student {
    . . . // private data not shown
    public Student(String name, int score) { . . . }
    public String getName() { . . . }
    public int getScore() { . . . }
    public void changeScore(int newScore) { . . . }
}

public static void sortDecreasingByScore(ArrayList<Student> students) {

    Collections.sort(students, new StuComparator

}

public class StuComparator implements Comparator<Student> {

    private int compare(Student st1, Student st2) {

        if (st1.getScore() > st2.getScore()) {

            return -1;

        }

        else if (st1.getScore() < st2.getScore()) {

            return 1;

        }

        return st1.equals(st2);

    }

}
```

Problem 4 [19 pts. total]

Part A (15). Write the complete class definition for a **Stack of ints** that uses an **array representation** (not `ArrayList`) such that all stack operations run in **amortized constant time** or better. Hint: Use the strategy such that if you run out of space in the array, you double its size. (The "amortized" part of the time is because of the need to increase the array size periodically.) You may not use any Java library classes or methods in your code, except the `Arrays.copyOf` method, described on the code handout. You do not have to write method comments for your class.

The complete interface for the `Stack` class for this problem is shown by example below (Note: method names shown in bold):

```
Stack s = new Stack();           // creates an empty stack
s.push(3);                        // pushes 3 onto the stack (has no return value)
s.push(0);                        // pushes 0 onto the stack
int val1 = s.pop();              // pops top element from the stack and returns its value.
                                // only legal on non-empty stack
int val = s.top();               // returns the top element (stack is unchanged)
                                // only legal on non-empty stack
if (s.isEmpty()) { // returns true if stack is empty, otherwise false
    System.out.println("stack is empty.");
}
```

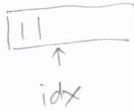
Space for your answer is given on this and the next page.

```
public class Stack {
    private int SIZE = 1024;

    private int[] st;
    private int idx;
    public Stack() {
        st = new int[SIZE];
        idx = 0;
    }

    public void push (int num) {
        st[idx] = num;
        idx++;
        // add checking
        if (idx == SIZE) {
            st = copyOf(st, SIZE * 2);
            SIZE = SIZE * 2;
        }
    }

    public boolean isEmpty() {
        return (idx == 0);
    }
}
```



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Problem 4 (cont.)

(additional space for your answer to Part A; Part B)

$idx = \text{size} - \text{length}$

```
public int pop () {  
    int val = -1;  
    if (idx > 0) {  
        val = st[idx];  
        idx--;  
    }  
    return val;  
}
```

```
public int top () {  
    int val = -1;  
    if (idx > 0) {  
        val = st[idx];  
    }  
    return val;  
}
```

Part B (4). Write a representation invariant for your class implementation:

$$0 \leq idx < \text{size} - 1$$

Problem 5 [14 points]

Part A (5). Earlier in the semester we discussed in detail a Names class that used a partially-filled array representation. **For each of the methods of this class, to the left of the method, write the big-O worst-case time for doing that method using the partially-filled array representation.**

```
// Stores a list of unique names in alphabetical order. Allows
// look-up, insert, and removal of elements in the list.
```

(PART A) BIG-O USING PARTIALLY-FILLED ARRAY (on left side)

```
public class Names {
```

```
    . . . [instance variables not shown]
```

```
    // Creates an empty names object
    public Names() { . . . }
```

```
    // Returns the number of names in the list
    public int numNames() { . . . }
```

```
    // Returns true iff target is present in names
    public boolean lookup(String target) { . . . }
```

```
    // Removes target from names, and returns true.
    // If target wasn't present in names, returns false and no change
    // made to names.
    public boolean remove(String target) { . . . }
```

```
    // Inserts newName into alphabetical names list.
    // Returns false and no change is made to names if name is already
    // present.
    public boolean insert(String newName) { . . . }
```

```
    // Prints the names in alpha order, one per line
    public void printNames() { . . . }
```

```
}
```

(PART C) BIG-O USING REP. FROM PART B (on right side)

$O(1)$

$O(1)$ [done ☺]

$O(1)$

$O(1)$

$O(1)$

$O(n)$

Part B (4). What Java class could we use to represent a Names object (i.e., type for the private data in Names) that is a big improvement over our original representation?

treeSet

Part C (5). To the *right* of each of the method headers above, write the big-O worst-case time or doing each operation using the representation you gave in part B.

Problem 6 [15 points]

Write a recursive method `oddVals`, which returns an ArrayList of all the odd values from an ArrayList of integers. The values returned must be in the same relative order as they were in the original array list, and the original array list must be unchanged by the method. A solution that doesn't use recursion will receive little to no credit. For full credit, your function must take no more than $O(n)$ time total. Note: you may create a helper method that does the actual recursion. Please refer to the code handout for a reminder of some ArrayList methods.

Some examples:

<u>vals</u>	<u>return value of oddVals(vals)</u>
[]	[]
[3]	[3]
[2, 4]	[]
[5, 3, 10, 3, 4, 9, 2]	[5, 3, 3, 9]
[7, 13]	[7, 13]

odd

num % 2 == 1

```
// returns a list of all the odd values from vals
// vals is unchanged by this method.
```

```
public static ArrayList<Integer> oddVals(ArrayList<Integer> vals) {
```

```
    ArrayList<Integer> num = new ArrayList<>();
```

```
    return helper(vals, 0, num);
```

```
}
```

ArrayList<Integer> num

```
public static ArrayList<Integer> helper(ArrayList<Integer> vals, int idx, ↓) {
```

```
    if (idx == vals.size() || vals.size() == 0)
```

```
        return num;
```

```
}
```

```
    int value = vals.get(idx);
```

```
    if (value % 2 == 0) {
```

```
        num.add(value);
```

```
        idx++;
```

```
}
```

```
    return helper(vals, idx, num);
```

```
}
```

Extra space for answers or scratch work. (DO NOT detach this page.)

If you put any of your answers here, please write a note on the question page directing us to look here. Also label any such answers here with the question number and part, and circle the answer.

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