PRINCE OF SONGKLA UNIVERSITY

FACULTY OF ENGINEERING

Department of Computer Engineering

Final Examination: Semester 2 **Academic Year**: 2008-2009

Date: 19th February, 2009 **Time**: 9:00 – **12:00 (3 hours)**

Subject Number: 240-421 **Room**: R200

Subject Title: Advanced Data Structures and Algorithms

Lecturer: Aj. Andrew Davison

Exam Duration: 3 hours

This paper has 5 pages.

Authorized Materials:

- Writing instruments (e.g. pens, pencils).
- Books (e.g. dictionaries) and calculators are **not** permitted.

Instructions to Students:

- *Answer questions in English.* Perfect English is **not** required.
- Attempt all questions.
- Write your answers in an answer book.
- Start your answer to each question on a new page
- Clearly number your answers.
- Any unreadable parts will be considered wrong.
- When writing programs, use good layout, and short comments; marks will not be deducted for minor syntax errors.
- The marks for each part of a question are given in brackets (...).

Question 1 (35 marks; 35 minutes)

a) Why can't you make an object of type `LinkedList<int>`? What should you do instead? [Do not include any code.] (10)

b) What is an iterator, and why are iterators necessary for generic programming? [Do not include any code.] (5)

c) Implement the method `counter()` by using an iterator to scan a `LinkedList` collection. Return an integer that gives the number of occurrences of the item `Object` in the list. (10)

```
int counter(LinkedList<?> aList, Object item)
```

d) Re-implement `counter()` *without* using an iterator. (5)

e) In what situations is a ListIterator especially useful? [Do not include any code.] (5)

Question 2 (20 marks; 20 minutes)

A 15-element array is to be sorted using a *radix sort*, utilizing 10 bins (queues) for the digits 0-9. The initial array is:

363, 251, 670, 84, 175, 45, 123, 389, 90, 8, 122, 7, 491, 593, 528

a) Draw the contents of the 10 bins after pass 0 of the radix sort. Also, show the new order of the array after pass 0. (4)

b) Draw the contents of the 10 bins after pass 1 of the radix sort. Also, show the new order of the array after pass 1. (3)

c) Draw the contents of the 10 bins after pass 2 of the radix sort. Also, show the final sorted array. (3)

d) Discuss the implementation and efficiency of radix sort. [Do not include any code.] (10)

Question 3 (25 marks; 25 minutes)

a) What are the main differences between a `TreeMap` and a `HashMap`? [Do not include any code.] (5)

b) Finish the implementation of the `MyInteger` class given below: (5)

```
public class MyInteger implements Comparable<MyInteger>
// a class that stores an int value
{
  private int value;

  public MyInteger(int n)
  // create a MyInteger instance with n as its value
  { . . . }

  public void setValue(int m)
```

```
  { . . . }

  public int getValue()
  { . . . }

  public void increment()
  // add 1 to the integer value
  { . . . }

  public String toString()
  { . . . }

  public int compareTo(MyInteger m)
  // compare objects by comparing their integer values
  { . . . }

}  // end of MyInteger class
```

c) Write code that employs a `TreeMap` whose entries use `MyInteger` keys and `MyInteger` values.

The code generates 5000 random integers in the range 0 to 9. Each integer is checked against the map. If the integer is the key of an existing entry, then that entry's value is incremented by 1. Otherwise a new entry is created with the integer as its key, and a value of 1.

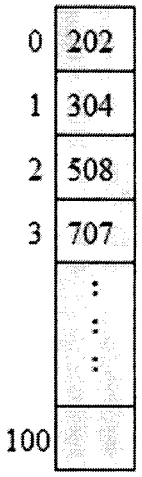
After all the randomly generated integers have been checked against the map, use the map to print out their occurrence frequencies. (15)

Question 4

(35 marks; 35 minutes)

The following hash table has space for 101 entries, but only the first 4 cells contain elements; the other cells are empty.

The hash function is `hash(element) = element%101`



a) Delete element 304 in cell 1 by clearing the cell so it is empty. What happens when you then search for 707? Explain in words why emptying a cell is not a good way to implement deletion in hash tables. (5)

b) Explain, without the use of code, a better way of representing deletion in hash tables. Illustrate your approach by repeating the 304 deletion and 707 search of part (a). (5)

c) Use *pseudo code* to explain how the following three methods would use your deletion approach:

- a delete() method that deletes a specified table element; (10)
- a locate() method that tries to locate a given element in the table; (10)
- a insert() method that inserts a given element in the table. (5)

Question 5

(35 marks; 35 minutes)

a) Heapify the following array: {7, 12, 5, 2, 15, 25, 1}, creating a max heap. Draw all the stages in the heapification, and summarize what is happening. Also show the resulting array. [Do not include any code.] (10)

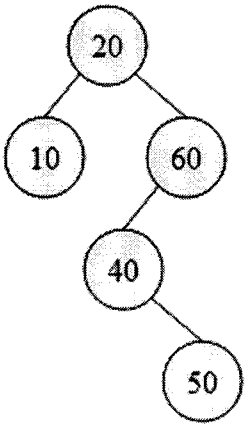
b) Perform a Heap sort on the array result from part (a). *Only draw the first three stages* in the sort, where the largest three elements of the array are put into ascending order position. Explain in words what is happening. [Do not include any code.] (15)

c) Draw the final sorted heap, and the corresponding sorted array. Briefly explain in words the number and types of operations that led to this result. [Do not include any code.] (10)

Question 6

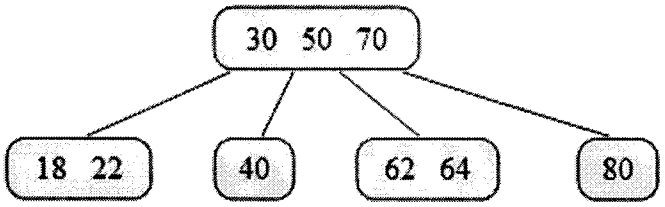
(30 marks; 30 minutes)

a) Carry out rotations on the following tree to create an AVL tree. (10)



Draw a diagram for each rotation of the tree, and explain each rotation in words.

b) Create the red-black tree for the following 2-3-4 tree. (10)



Draw a diagram for each transformation of the tree, and explain each transformation in words.

Make sure you clearly indicate (via words or colour) which of the nodes of the resulting red-black tree are RED, and which are BLACK.

c) Explain the necessary properties of a red-black tree. (10)

--- End of Examination ---