QUEENS COLLEGE Department of Computer Science
CSCI 313 Practice problems on Priority Queues and Heaps

Instructor: Alex Ryba

These problems were given on exams for this course. Some older problems did not make use of generics in Java, but generic implementations are now required in this course.

Problem 1 A generic priority queue is implemented as a heap so that n entries of comparable type K occupy elements $1, 2, 3, \ldots (n+1)$ of an array *data* in the heap. Usual heap order and heap shape requirements are in force. (Note this uses slightly different array elements from the implementation described in class and in the textbook.) A skeleton for the class is as follows:

```
public class HeapPriorityQueue  // class title line to be completed as (a)
{  private K data[];  private int size = 0;  private int capacity = 100;
   // constructor  to be coded as (b)
   public void insert(K x) throws Exception {
      if (size >= capacity - 2) throw new Exception("Priority Queue Full");
      data[++size] = x;
      bubbleUp(size);
   }
   public K removeMin() throws Exception {  // omitted
   private void swapData(int n, int m) { // omitted, swaps entries n and m
   private void bubbleUp(int n) {   // omitted  to be coded as (c)
   private void bubbleDown(int n) { // omitted
}
```

(a) **Write the complete class title line, including a clause that makes it implement a *PriorityQueue*.**

(b) **Implement a constructor with no arguments**.

(c) **Implement the method bubbleUp**.

Problem 2 The standard `interface PriorityQueue` and `class HeapPriorityQueue` include the following code.

```
interface PriorityQueue<K extends Comparable<K>> {
   public void add(K x) throws Exception;
   public K removeMin() throws Exception;
}

class HeapPriorityQueue<K extends Comparable<K>> implements
      PriorityQueue<K> {
   private K data[];  // the root is stored at index 0 in the array
   private int size;
   private int capacity;
// constructors, add and removeMin method code omitted
/* methods with titles
   void bubbleUp(int n)
   void bubbleDown(int n)
   void swapData(int n, int m)
  are available, but the code is not shown here */
}
```

Write complete code for a non-standard `HeapPriorityQueue` method `removeSecondMin` that efficiently removes and returns the second minimum element from the data structure. Your solution can make use of the methods `bubbleUp`, `bubbleDown` and `swapData` but must not apply the constructor or either of the methods `add` and `removeMin`.

For example, if the array contains the following elements:

1, 2, 3, 4, 5,

It should be changed by `removeSecondMin` to

$$1,\ 4,\ 3,\ 5,$$

Inefficient and excessively complicated solutions will lose points.

Answer:

Problem 3 (a) What two properties of a binary tree make it a heap?

(b) Give a Java implementation method for the method:

```
public static <K extends Comparable<K>> boolean hasHeapOrder(BNode<K> r)
```

Here r is a node in a Binary Tree, so that r has instance variables $data$, $parent$, $left$ and $right$. The method should return true if the subtree rooted at r satisfies the heap ordering requirement.

Problem 4 (a) What two properties of a binary tree make it a heap?

(b) Give either a pseudocode outline (or for extra credit, a Java method) for an algorithm:

```
public static <K> boolean hasHeapShape(BNode<K> r)
```

That returns true, if the subtree rooted at r satisfies the heap shape requirement.