Family Name: ..... **Other Names:** .....

Student ID: ..... **Signature** .....

COMP 103 : Test

2020, Jan 8

Instructions

- Time allowed: **50 minutes**
- Attempt **all** questions. There are 50 marks in total.
- Write your answers in this test paper and hand in all sheets.
- If you think some question is unclear, ask for clarification.
- Brief Java documentation is provided with the test
- This test contributes 15% of your final grade
  (But your mark will be increased to your exam mark if that is higher.)
- You may use dictionaries.
- You may write notes and working on this paper, but make sure your answers are clear.

Questions	**Marks**	
1. Properties of Collections	[12]	
2. Using Queues in Simulations	[13]	
3. Using Collections	[10]	
4. Cost of Algorithms	[7]	
5. Recursion	[8]	
	TOTAL:	

SPARE PAGE FOR EXTRA ANSWERS

Cross out rough working that you do not want marked.
Specify the question number for work that you do want marked.

Question 1. Properties of Collections **[12 marks]**

For these questions, circle "true" or "false" for each property. (Note some properties may be true for more than one type.)

(a) **[4 marks]** For a Queue, state whether each property is true or false.

true/false	:	The order of items in the collection is important
true/false	:	Items must have a natural ordering to be stored in the collection.
true/false	:	The first item added is the last item to be removed
true/false	:	The collection can contain duplicate items

(b) **[4 marks]** For a Map, state whether each property is true or false.

true/false	:	The order of values in the collection is important
true/false	:	To remove a value, you must specify its key
true/false	:	The collection cannot contain any duplicate values
true/false	:	Items in the collection are stored as key-value pairs

(c) **[4 marks]** For a Set, state whether each property is true or false.

true/false	:	An item can be only be removed by specifying its index
true/false	:	The order of items in the collection is important
true/false	:	The collection cannot contain any duplicate items
true/false	:	Items can be added at a specified position

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Question 2. Using Queues in Simulations **[13 marks]**

For this question, you are to extend a simple simulation program.

The program simulates the creation and delivery of pizza for a fast-food outlet. The outlet has two queues: kitchen and delivery. The kitchen queue holds all of the orders that need to be cooked. Once an order is cooked, it is moved to the delivery queue and delivered to the customer.

At each tick:

- a new Order may be created and added to the kitchen queue.
- the Orders at the heads of both queues are advanced one tick
- if the Order at the head of the kitchen queue is complete, it is removed from the queue and added to the delivery queue.
- if the Order at the head of the delivery queue is complete, it is removed from the queue.
- the queues are re-displayed.

The owner of the outlet wants to simulate what would happen if they hired more delivery drivers. You must extend the program to allow for multiple delivery drivers, each with their own queue.

- There can be any number of delivery drivers, so the queues should be stored in a List.
- When an order is finished in the kitchen, it should be added to the shortest delivery queue.
  - For convenience, a separate method (`getShortestQueue()`) will be used to find the shortest queue.
- On every time tick, the first job on every queue should be advanced.

(Question 2 continued on next page)

(Question 2 continued)

Here is the one-driver program:

```
public class Simulation{
    private boolean running = false;

    private Queue<Order> kitchen;
    private Queue<Order> delivery;

    public void setup(){
        running = false;
        kitchen = new ArrayDeque<Order>();
        delivery = new ArrayDeque<Order>();
    }

    public void run(){
        int time = 0;
        running = true;
        while (running){
            time++;
            if (Math.random()<0.2){
                Order o = new Order();
                kitchen.offer(o);
            }
            if (!kitchen.isEmpty()){
                Order topOrder = kitchen.peek();
                topOrder.advanceCookingByOneTick();
                if (topOrder.isCooked()){
                    delivery.offer(kitchen.poll());
                }
            }
            if (!delivery.isEmpty()){
                Order topOrder = delivery.peek();
                topOrder.advanceDeliveryByOneTick();
                if (topOrder.isDelivered()){
                    delivery.poll();
                }
            }
            display(kitchen, 1);    // redisplay queue on row 1 of the window
            display(delivery, 2);   // redisplay queue on row 2 of the window
        }
    }
}
```

(Question 2 continued on next page)

(Question 2 continued)

(a) **[5 marks]** Complete the getShortestQueue() method that will find and return the delivery queue with the least number of orders

```
public class Simulation{
    public static final int NUM_DELIVERY_DRIVERS = 5;
    private boolean running = true;

    private Queue<Order> kitchen ;
    private List<Queue<Order>> deliveryQueues;

    public void setup() {
        running = false;
        kitchen = new ArrayDeque<Order>();
        deliveryQueues = new ArrayList<Queue<Order>>(); //new
        for (int i =0; i< NUM_DELIVERY_DRIVERS; i++){       //new
            deliveryQueues.add(new ArrayDeque<Order>()); //new
        }
    }

    private Queue<Order> shortestDeliveryQueue() {









    }
```

(Question 2 continued on next page)

(Question 2 continued)

(b) **[8 marks]** Complete the run method for the simulation with multiple drivers

```
    public void run() {









    }
}
```

Question 3. Using Collections **[10 marks]**

Complete the following analyseText(...) method which is given a List of words (Strings) and counts the number times each word appears in the text. It also creates a Set of verbs (action words) and nouns (name words) that appear in the text.

You can assume that there are methods boolean isVerb(String s) and boolean isNoun(String s) that will return true if the provided String is a verb or a noun.

The method should be efficient: if the List has n words, then the method should run in O(n) time.

```
Set<String> verbs;
Set<String> nouns;
Map<String, Integer> wordCounts;

 public void analyseText( List<String> words){









 }
```

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Cross out rough working that you do not want marked.
Specify the question number for work that you do want marked.

Question 4. Cost of Algorithms **[7 marks]**

What is the big-O cost of the following method that uses a PriorityQueue to sort a list?

- write the big-O cost of performing each line with a comment
- write the number of times each of the lines will be performed,
- write the total cost of the algorithm (big-O) at the bottom of the box

```
public void sortList ( List<String> words){
    Queue<String> queue = new PriorityQueue<String>();

    for( String word : words) {
        queue. offer (word);                    // cost= O(      )   times=
    }
    words. clear ();                            // cost= O(      )   times=
    while (!queue.isEmpty()) {
        words.add( queue. poll () );            // cost= O(      )   times=
    }
}                                               Total Cost = O(          )
```

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Cross out rough working that you do not want marked.
Specify the question number for work that you do want marked.

Question 5. Recursion **[8 marks]**

(a) **[4 marks]** Complete the following recursive drawTower(x, y, width) method to draw a "tower" made of stacked rectangles.

- You must use a "first-and-rest" recursion: drawTower(...) should draw the first rectangle and then call itself recursively to draw the rest of the rectangles.
- The first rectangle should be centered at (x,y) with the provided width. The rectangle's height should be 2/3 * width.
- The next rectangle should be height-2 pixels above, and should be 6 pixels smaller in width.
- It should continue to draw rectangles as long as the width is larger than 3.

For example, drawTower(100, 300, 30) should output the following:

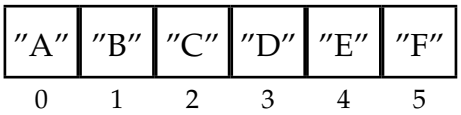
```
public void drawTower(double x, double y, double width){




}
```

Hint: you can use the method UI.drawRect(left, top, width, height) to draw a rectangle.

(Question 5 continued on next page)

(Question 5 continued)

(b) **[4 marks]** Suppose the variable letters contains the following List of 6 Strings:



What will printList(letters, 0, 5) print out?

```
/** print the letters in the list */
public void printList (List<String> letters, int start, int end){
    if ( start <= end) {
        int mid = (start + end)/2;
        UI.print( letters.get(mid));
        printList ( letters , start , mid−1);
        printList ( letters , mid+1, end);
    }
}
```

Answer:

* * * * * * * * * * * * * * *

Documentation

Brief, simplified specifications of some relevant Java collection types and classes.

Note: E stands for the type of the item in the collection.

```
interface Collection<E>
   public boolean isEmpty()                    // cost: O(1) for all standard collection classes
   public int size()                           // cost: O(1) for all standard collection classes
   public void clear()
   public boolean add(E item)
   public boolean contains(Object item)
   public boolean remove(Object element)

interface List<E> extends Collection<E>
   // Implementations: ArrayList
   public boolean isEmpty()
   public int size()
   public void clear()
   public E get(int index)                     // cost: O(1)
   public E set(int index, E element)          // cost: O(1)
   public boolean contains(Object item)        // cost: O(n)
   public void add(int index, E element)       // cost: O(n) (unless index is close to the end.)
   public E remove(int index)                  // cost: O(n) (unless index is close to the end.)
   public boolean remove(Object element)       // cost: O(n)

interface Set extends Collection<E>
   // Implementations: HashSet, TreeSet
   public boolean isEmpty()
   public int size()
   public void clear()
   public boolean add(E item)                  // cost: O(1) for HashSet, O(log(n)) for TreeSet
   public boolean contains(Object item)        // cost: O(1) for HashSet, O(log(n)) for TreeSet
   public boolean remove(Object element)       // cost: O(1) for HashSet, O(log(n)) for TreeSet

interface Map<K, V>
   // Implementations: HashMap, TreeMap
   public V get(K key)                 // cost: O(1) for HashMap, O(log(n)) for TreeMap
   public V put(K key, V value)        // cost: O(1) for HashMap, O(log(n)) for TreeMap
   public V remove(K key)              // cost: O(1) for HashMap, O(log(n)) for TreeMap
   public boolean containsKey(K key)   // cost: O(1) for HashMap, O(log(n)) for TreeMap
   public Set<K> keySet()              // cost: O(1)
   public Collection<V> values()       // cost: O(1)
   // (get returns null if the key is not present)
   // (get put and remove return the old value, if any)
```

```
interface Queue<E> extends Collection<E>
   // Implementations: ArrayDeque, LinkedList, PriorityQueue
   public boolean isEmpty()
   public int size()
   public void clear()
   public E peek()                  // cost: O(1) for ArrayDeque, LinkedList, O(1) for PriorityQueue
   public E poll()                  // cost: O(1) for ArrayDeque, LinkedList, O(log(n)) for PriorityQueue
   public boolean offer(E element)  // cost: O(1) for ArrayDeque, LinkedList, O(log(n)) for PriorityQueue
   // (peek and poll return null if the queue is empty)

class Stack<E> implements Collection<E>
   public boolean isEmpty()
   public int size()
   pubic void clear()
   public E peek()                  // cost: O(1)
   public E pop()                   // cost: O(1)
   public E push(E element)         // cost: O(1)
   // (peek and pop return null if the queue is empty)


class Collections
   public void sort(List<E> list);                          // cost = O(n log(n)), but O(n) if almost sorted
   public void sort(List<E> list, (E e1, E e2)->{...});     // cost = O(n log(n)), but O(n) if almost sorted
   public void swap(List<E> list, int i, int j);            // cost = O(1)
   public void reverse(List<E> list);                       // cost = O(n)
   public void shuffle(List<E> list);                       // cost = O(n)


interface Comparable<E> // All Comparable objects have a compareTo method:
   public int compareTo(E other);
          // returns
          //     -ve if this comes before other;
          //     +ve if this comes after other,
          //       0 if this and other are the same
```