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

ID Number: ..... **Signature** .....

COMP 103: Test 2

14 Sept, 2012

Model Solutions

Instructions

- Time allowed: **35 minutes**
- There are 25 marks in total.
- Answer **all** the questions.
- The appendix contains the sorting algorithms and brief collection class documentation.
- If you think some question is unclear, ask for clarification.
- This test will contribute 10% of your final grade,
  (But your mark will be boosted up to your exam mark if that is higher.)
- You may use paper translation dictionaries, and calculators without a full set of alphabet keys.
- Write your answers in the boxes in this test paper and hand in all sheets. You may ask for additional paper if you need it.
- You may write notes and working on this paper, but make sure it is clear where your answers are.

Questions	**Marks**	
1. Sorting and Searching Algorithms	[10]	
2. Implementing a Collection	[10]	
3. Recursive Algorithms	[5]	
	TOTAL:	

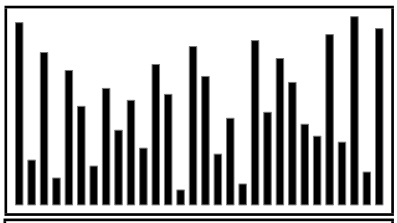
SPARE PAGE FOR EXTRA ANSWERS

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

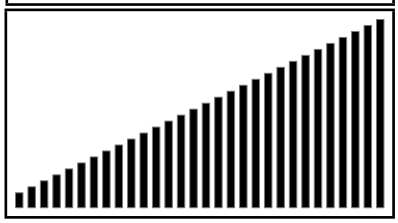
Question 1. Sorting Algorithms [10 marks]

Suppose we want to sort a collection of sticks according to height:

From:



To:

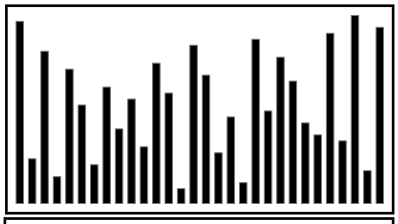


Each of the following diagrams show the state of the sticks part way through sorting using a different sorting algorithm. For each diagram, say which algorithm is being used, and give a brief explanation for your choice.

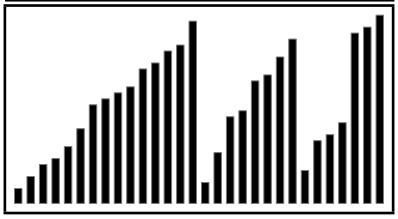
The possible algorithms are selection sort, bubble sort, insertion sort, recursive merge sort, and quicksort.

(a) [2 marks]

From:



Part way:



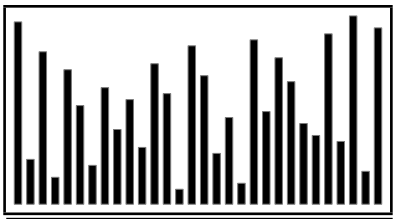
Sorting Algorithm: MergeSort

Explanation: The first half is the items from the first half sorted; the 3rd and 4th quarter are sorted, but not yet merged.

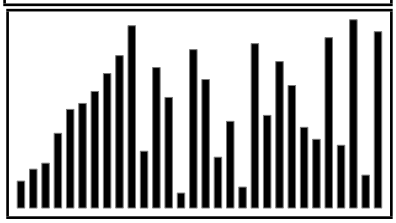
(Question 1 continued on next page)

(b) [2 marks]

From:



Part way:

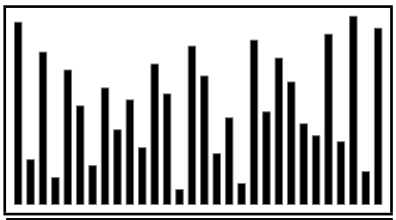


Sorting Algorithm: Insertion Sort

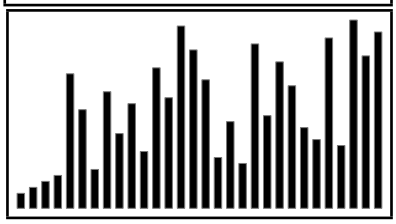
Explanation: The first 10 items have been put in order, the rest of the items have not be moved at all.

(c) [2 marks]

From:



Part way:



Sorting Algorithm: Selection Sort

Explanation: The first 4 items have been swapped into the correct place.

(Question 1 continued on next page)

(Question 1 continued)

(d) [2 marks] Under what circumstances will it be faster to use Insertion Sort to sort an array than to use QuickSort?

When the items in the array are almost sorted, eg, with at most a few items out of place, or each item just a small distance from where they should be.
Also, when the size of the array is very small (eg, less than 5)

(e) [2 marks] Explain what it means for a sorting algorithm to be stable, and give one example of a stable sorting algorithm and one example of an unstable sorting algorithm.

Explanation: A stable sorting algorithm will preserve the order of two items that are equal

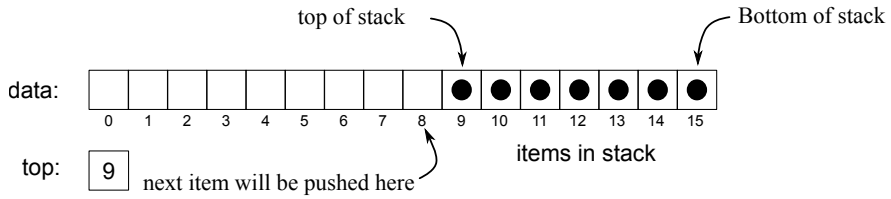
An example stable algorithm: Insertion Sort, Merge Sort, Bubble Sort.

An example unstable algorithm: Selection Sort, Quick Sort.

Question 2. Implementing a Collection [10 marks]

This question concerns a YarraStack class which implements a Stack collection using an array. YarraStack objects have a data field to hold the array of values, and a top field to hold the position of the value at the top of the stack. It stores the items at the right end of the array, (rather than from the beginning of the array), so the item at the bottom of the stack (the first item added) will be at position length-1.

The following diagram shows a stack with seven values in it.



Part of the YarraStack class is shown below:

```
public class YarraStack <E> extends AbstractCollection <E> {

    private static final int INITIALCAPACITY = 8;
    private E[ ] data;
    private int top;

    public YarraStack(){
        data = (E[ ]) new Object[INITIALCAPACITY];
        top = data.length;                          // Stack is initially empty
    }

    public E peek(){
        if (top==data.length) throw new EmptyStackException();
        return data[top];
    }
```

(a) [2 marks] Complete the following size method which should return the number of items in the stack. (Note, it must compute the size from the values in the fields.)

```
    public int size () {
        return data.length−top;



    }
```

(Question 2 continued on next page)

(Question 2 continued)

(b) [4 marks] Complete the following push method which should ensure there is room in the array, and add the new value to the top of the stack. It should return the value it added.

```
/** Pushes a value onto the top of the stack.
 * Returns the value being pushed */
public E push(E item){
    if (item == null) throw new IllegalArgumentException("null argument");
    ensureCapacity();
    top--;
    data[top] = item;
    return item;




}
```

(c) [4 marks] Complete the following ensureCapacity method which should ensure that the data array has room to add a new value. If the array is currently not full, it should simply return. Otherwise, it should create a new array, double the size, copy the values over, and reset the value of top.

```
private void ensureCapacity () {

    if (top > 0) return;
    E [ ] newArray = (E[ ]) new Object[data.length*2];
    for ( int i = 0; i< data.length; i++){
        newArray[i+data.length] = data[i ];
    }
    top = data.length;
    data = newArray;

//An alternative version:
    if (top > 0) return;
    E [ ] old = data;
    data = (E[ ]) new Object[data.length*2];
    top = data.length;
    for ( int i = old.length-1; i>=0; i--){
        data[--top] = old[i ];              // same as   top--;
    }                                       //           data[top] = old[i];


}
```

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 3. [5 marks]

Consider the following choose method which returns a value from an array. It uses the partition method from QuickSort (included in the appendix).

```
public String choose(String[ ] data, int low, int high, int choice){
    if (low+1 == high) { return data[low]; }
    int mid = partition (data, low, high);
    if (choice<mid)    { return choose(data, low, mid, choice); }
    else               { return choose(data, mid, high, choice); }
}
```

(a) [1 mark] If the array myData contains the following strings, what value will be returned by

choose(myData, 0, 10, 7)

Hint: show any working to get partial credit.

owl	rat	fox	vet	elk	hog	zoo	yak	jay	pig
0	1	2	3	4	5	6	7	8	9

vet
"vet" would be at position 7 if the list were sorted

(b) [2 marks] Explain the function of *choose* - what it does in general.

choose will return the choice'th smallest value in the array. It will also partially rearrange the values in array.

(c) [2 marks] State the average cost of choose when called on an array with n values and justify your answer.
You may express your answer using big(O) notation. State whether the cost depends on the value of the last argument (choice).

On average, the cost will be about $2n$ comparisons, ie $O(n)$. partition will be called on the whole array (cost n), then on about half the array ($cost n/2$), then on about a quarter of the array (cost $n/4$), etc. The sum of those costs is about 2n.

****

Appendix: Selection, Insertion, Bubble, QuickSort

```
public void selectionSort(String[ ] data){
    for ( int place=0; place<data.length−1; place++){
        int minIndex = place;
        for ( int sweep=place+1; sweep<data.length; sweep++){
            if (data[sweep].compareTo(data[minIndex]) < 0)
                minIndex=sweep;
        }
        swap(data, place, minIndex);
    }
}

public void insertionSort(String[ ] data){
    for ( int i=1; i<data.length; i++){
        String item = data[i];
        int place = i;
        while (place > 0 && item.compareTo(data[place−1]) < 0){
            data[place] = data[place−1];        // move up
            place−−;
        }
        data[place]= item;
    }
}

public void bubbleSort(String[ ] data){
    for ( int top=data.length−1; top>0; top−−){
        for ( int sweep=0; sweep<top; sweep++)
            if (data[sweep].compareTo(data[sweep+1]) >0)
                swap(data, sweep, sweep+1);
        }
}

public void quickSort(String[ ] data, int low, int high) {
    if (high−low < 2)       // only one item to sort.
        return;
    else {      // split into two parts, mid = index of boundary
        int mid = partition (data, low, high);
        quickSort(data, low, mid);
        quickSort(data, mid, high);
    }
}
private int partition (String[ ] data, int low, int high) {
    String pivot = data[(low+high)/2];
    int left = low−1;
    int right = high;
    while( left < right ) {
        do { left ++; } while ( left <high && data[left].compareTo(pivot) < 0);
        do { right−−; } while (right>=low &&data[right].compareTo(pivot) > 0);
        if ( left < right) { swap(data, left , right ); }
    }
    return left ;
}
```

Appendix: MergeSort

```
public  void mergeSort(String[ ] data) {
    String[ ] other = new String[data.length];
    for( int i=0; i<data.length; i++) { other[i]=data[i]; }
    mergeSort(data, other, 0, data.length);
}

public void mergeSort(String[ ] data, String[ ] temp, int low, int high) {
    if (low < high−1) {
        int mid = ( low + high ) / 2;
        mergeSort(temp, data, low, mid);
        mergeSort(temp, data, mid, high);
        merge(temp, data, low, mid, high);
    }
}

public void merge(String[ ] from, String[ ] to, int low, int mid, int high) {
    int index = low;        //where we will put the item into "to"
    int indxLeft = low;     //index into the lower half of the "from" range
    int indxRight = mid; // index into the upper half of the "from" range
    while (indxLeft<mid && indxRight < high) {
        if ( from[indxLeft].compareTo(from[indxRight]) <=0 )
            to[index++] = from[indxLeft++];
        else
            to[index++] = from[indxRight++];
    }
    // copy over the remainder. Note only one loop will do anything.
    while (indxLeft<mid)
        to[index++] = from[indxLeft++];
    while (indxRight<high)
        to[index++] = from[indxRight++];
}
```

Appendix: Collections

```
interface Collection<E>
    public boolean isEmpty()
    public int size()
    public boolean add(E item)
    public boolean contains(Object item)
    public void remove(Object element)
    public Iterator<E> iterator()

interface List<E> extends Collection<E>
    // Implementations: ArrayList, LinkedList
    public E get(int index)
    public void set(int index, E element)
    public void add(int index, E element)
    public void remove(int index)
    // plus methods inherited from Collection

interface Set extends Collection<E>
    // Implementations: ArraySet, HashSet, TreeSet
    // methods inherited from Collection

interface Queue<E> extends Collection<E>
    // Implementations: ArrayQueue, LinkedList
    public E peek ()                    // returns null if queue is empty
    public E poll ()                    // returns null if queue is empty
    public boolean offer (E element)

class Stack<E> implements Collection<E>
    public E peek ()                    // returns null if stack is empty
    public E pop ()                     // returns null if stack is empty
    public E push (E element)

interface Map<K, V>
    // Implementations: HashMap, TreeMap, ArrayMap
    public V get(K key)                 // returns null if no such key
    public V put(K key, V value)        // returns old value, or null
    public V remove(K key)              // returns old value, or null
    public boolean containsKey(K key)
    public Set<K> keySet()

public class Collections
    public void sort(List<E>)
    public void sort(List<E>, Comparator<E>)
    public void shuffle(List<E>, Comparator<E>)
```