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

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

COMP 103 : Test 4

2021, Feb 3

Instructions

- Time allowed: **50 minutes**
- Attempt **all** questions. There are 30 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 10% of your final grade
- You may use dictionaries.
- You may write notes and working on this paper, but make sure your answers are clear.

Questions	**Marks**	
1. Binary Trees	[10]	
2. General Trees	[20]	
	TOTAL:	

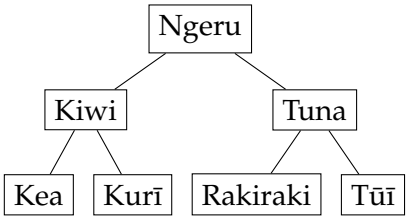
SPARE PAGE FOR EXTRA ANSWERS

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

Question 1. Binary Trees **[10 marks]**

(a) **[2 marks]** Suppose a binary tree is 5 layers deep. What is the *maximum* number of nodes that can fit in this tree before a new layer needs to be added?

(b) **[2 marks]** For the binary tree below, give the order the nodes would be printed in if they were printed via a **post-order depth-first traversal.**



(c) **[6 marks]** Complete the following method, which should do an **in-order depth-first traversal** of a tree and print each node as it goes. It should visit the children from left to right.
The tree is made of BTNodes, which have the following methods available to you:

```
class BTNode {
        String getValue(); // get the value of this node
        BTNode getLeft(); // get the left child (null if none)
        BTNode getRight(); // get the right child (null if none)
}
```

```
public void printTree(BTNode node) {




}
```

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Cross out rough working that you do not want marked.
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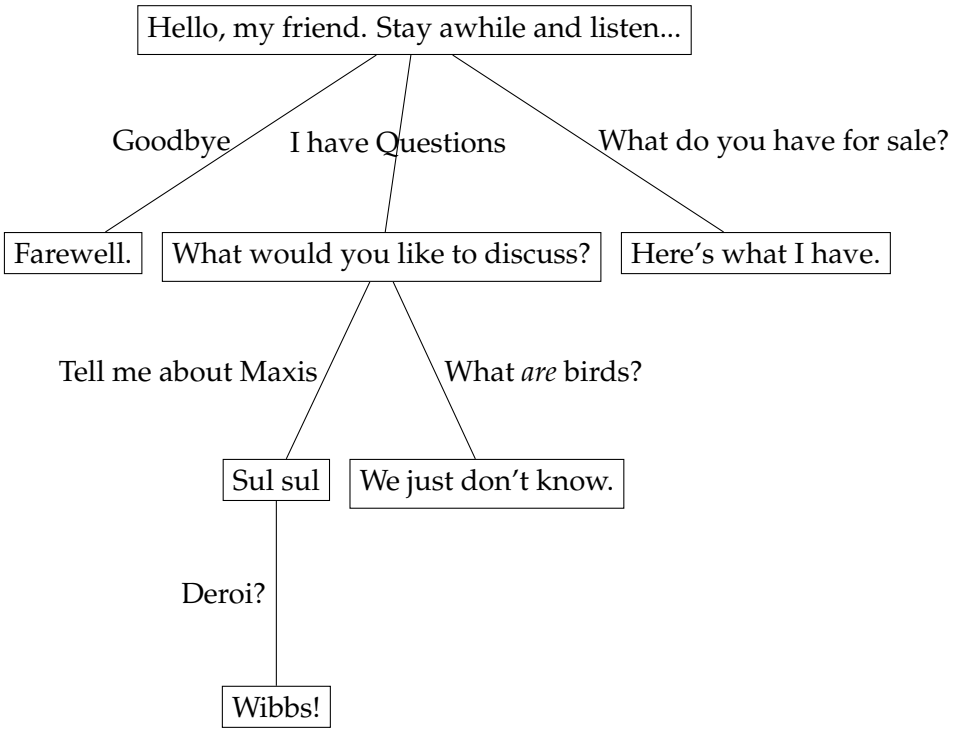
Question 2. General Trees **[20 marks]**

Suppose you are working on a video game that allows the player to have detailed text-based conversations with non-player characters. You have decided to use a Tree to represent each conversation, with player choices dictating which option happens next.

- The program uses GTNodes that contains String objects.
- The GTNode class is iterable, and iterates through the node's children.

```
class GTNode<E> implements Iterable<GTNode<E>>:
    public GTNode(E item);                                  // constructor
    public E getItem();                                     // return item in the node
    public int numChildren();                               // return number of children of the node
    public void addChild(GTNode<E> child);                  // add a child
    public void addChild(int pos, GTNode<E> child);         // add a child at a specific position
    public GTNode<E> getChild(int i);                       // return i'th child
    public void removeChild(int i);                         // remove i'th child
    public void Iterator <GTNode<E>> iterator();            // get iterator for children
```

One example conversation tree is shown below. The labels on the edges indicate the player's response and are provided only for clarity – you do not need to worry about them!



(Question 2 continued on next page)

(Question 2 continued)

(a) **[10 marks]** Complete the following printConversationTree(...) method which is given the root node of the tree, and should use recursion to print out all the dialogue in the tree, using indentation to show the structure.

For example, the tree on the previous page should be printed as:

```
Hello, my friend. Stay awhile and listen...
    Farewell
    What would you like to discuss?
        Sul Sul
            Wibbs!
        We just don't know.
    Here's what I have.
```

Hint: You should create a recursive function with more arguments.

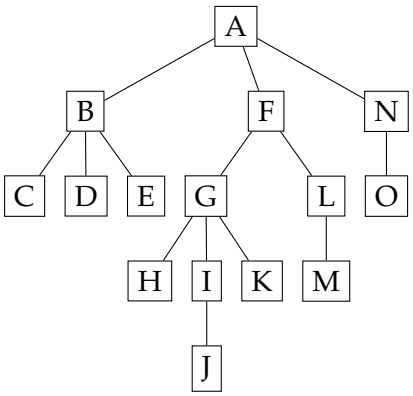
```
public void printConversationTree(GTNode<String> node){




}
```

(b) **[4 marks]** what is the name for the tree traversal you used for printConversationTree

(Question 2 continued on next page)

(Question 2 continued)

(c) **[6 marks]** Suppose you have the general tree shown below:



In which order would be nodes the processed if you ran a method that performed a **breadth-first** traversal of the tree, adding the children of a node to the queue from **right-to-left**?

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

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.

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
```