FACULTY OF SCIENCE

ACADEMY OF COMPUTER SCIENCE AND SOFTWARE ENGINEERING

MODULE	CSC03A3/CSC3A10 COMPUTER SCIENCE 3A
CAMPUS	AUCKLAND PARK CAMPUS (APK)
EXAM	SSA EXAM 2019

DATE: 2019-07	**SESSION:** 08:00 - 11:00
ASSESOR(S):	PROF D.T. VAN DER HAAR MR R. MALULEKA
EXTERNAL MODERATOR:	PROF J. GELDENHUYS (SUN)
DURATION: 180 MINUTES	**MARKS:** 150

Please read the following instructions carefully:

1. Answer **all** the questions
2. Write *cleanly* and *legibly*.
3. You may use a non-programmable calculator to answer the questions.
4. This paper consists of 6 pages.

QUESTION 1

(a) Consider the Java source code below and answer the questions that follow. (5)

```java
public int Fib(int k){
  if (k == 1)
    return k;
  else
    return Fib(k-1) + Fib(k-2);
}
```

1. What type of recursion is being used and explain why it can be classified as this?
2. List two other types of recursion that exist.

(b) Discuss the **short circuiting** feature of Java's logical operators for boolean values (&& and ||), as well as its benefit. (4)

(c) How would you go about **adding** an element **after** a given node in a **doubly linked list**? You may use pseudo code or diagrams to support your answer. (6)

Total: 15

QUESTION 2

(a) For each of the following pairs of functions, what is the asymptotic relationship between these functions? (6)

1. $\log_2 n$ and $\log_{10} n$
2. n^k and c^n, where k and c are constants
3. 8^n and 4^n

(b) Provide Java source that represents an **iterative** version of the following function. (5)

```java
public static long f(int n) {
  if (n <= 1) return n;
  else return f(n-1) + f(n-2);
}
```

(c) Discuss the **Sequence ADT** together with an example of where it can be applied. (4)

Total: 15

QUESTION 3

(a) Consider the following List Interface and write a class *Stack* that makes use of the List Interface and the Adapter design pattern to realize a *Stack ADT*. **Note: You do not have to implement the List methods** (10)

```java
public interface List<T> {
public Node<T> addAfter(Node<T> elem, T item);
public Node<T> addFirst(T item);
public Node<T> addLast(T item);
public T remove(Node<T> elem);
public Node<T> search(T elem);
public Node<T> first();
public boolean isEmpty();
public Integer size();
}
```

(b) Briefly define the concept of a **Priority Queue** and describe what an **Entry** in a Priority Queue looks like. Be sure to include **three properties** that are used to achieve total order relations for entries in a Priority Queue. (5)

Total: 15

QUESTION 4

(a) Provide psuedo code for performing an **Euler tour** on a binary tree T. (5)

(b) Illustrate the execution of the **bottom-up construction of a heap** on the following sequence. You only need to provide a graphic representation of the heap at each stage in the construction, including any intermediate operations. (10)

(3, 42, 22, 7, 9, 55, 32, 13, 27, 9, 8, 20, 11, 21, 37)

Total: 15

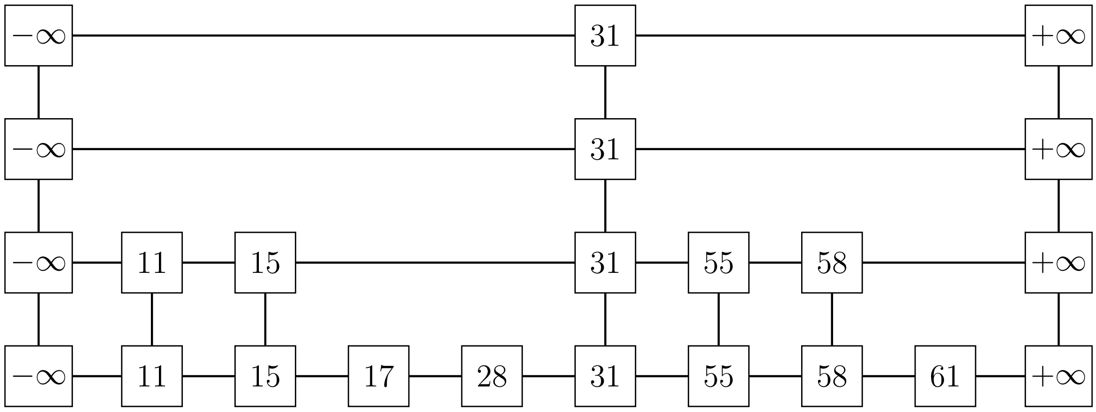
QUESTION 5

(a) Given a hash function $h(x) = xmod7$ for a hash table that uses **linear probing**, redraw the hash table below and **insert** the keys 18, 41, 22, 44, 59, 32, 31, 73 in this order. (8)

0	1	2	3	4	5	6	7	8	9	10	11

(b) Provide Java or pseudo source code for the **remove** method (that removes a key-pair e of type $Entry < K, V >$ from List S) in a **List-Based Dictionary**. (6)

(c) Analyse the skip list below and illustrate using diagrams how you would **insert** an entry with a key of 59 and 2 heads coin flips. (6)



Total: 20

QUESTION 6

You have been asked to do a presentation for a company (**Egumbini**) that is helping the South African government to solve the public school allocation problem. Many scholars go without schooling in the first few months of every school year, because schools are decommissioned or the scholar's family relocates to a new geographic region and it is difficult to find a school for them when there already so many full schools. The company requires you to present a discussion on **three** of the best data structures and algorithms that can be used to efficiently determine the best school (the element in the data structure) that should be allocated to a particular scholar (you can assume that memory usage is not a concern). You should discuss **how** the three options will be implemented, in each case listing their **advantages**, **disadvantages**, and **runtime efficiencies**.

Total: 15

QUESTION 7

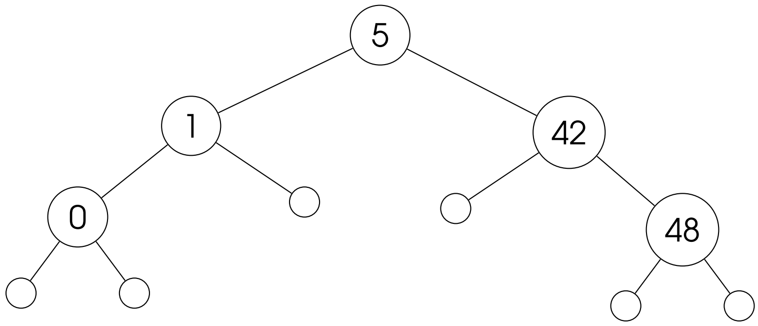
Consider the following AVL tree provided below. Draw the AVL tree state after each of the following operations. If the tree is rebalanced draw the state before and after it being balanced. Removal operations should follow from the tree that resulted from the insertion operations.

1. Insert nodes that contain the following keys: (inserted one-by-one, in the given order)

   26, 35, 42, 23, 4, 22, 2

2. Delete nodes that contain the following keys: (removed one-by-one, in the given order)

   10, 5



Total: 15

QUESTION 8

Consider the following Red-Black tree provided below. Draw the Red-Black tree state after each of the following operations. If the tree is rebalanced draw the state before and after it being balanced. Removal operations should follow from the tree that resulted from the insertion operations.Removal operations should follow from the tree that resulted from the insertion operations.

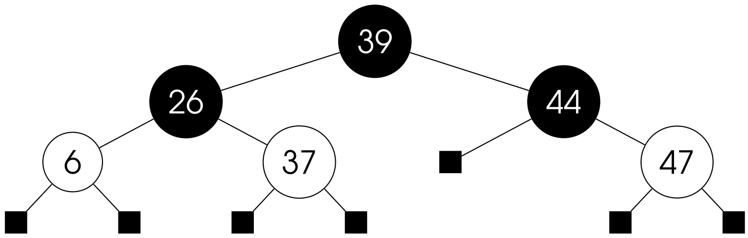
1. Insert nodes that contain the following keys: (inserted one-by-one, in the given order)

   42, 12, 18, 6

2. Delete nodes that contain the following keys: (removed one-by-one, in the given order)

   42, 37, 18, 6, 47, 6, 12, 44

The Red-Black tree is in the current state:



Total: 20

QUESTION 9

(a) Provide a diagram that demonstrates the relationship between the structure of a **Red-Black Tree** and a **2-4 Tree**. (5)

(b) Consider the following description of a graph. (10)

vertex	adjacent verticies
1	(2,3,4)
2	(1,3,4)
3	(1,2,4)
4	(1,2,3,6)
5	(6,7,8)
6	(4,5,7)
7	(5,6,8)
8	(5,7)

Provide a **graphical representation** of the above graph.

(c) Provide the steps for a **Depth First Search** graph traversal. (5)

Total: 20

— End of paper —