FACULTY OF SCIENCE

ACADEMY OF COMPUTER SCIENCE AND SOFTWARE ENGINEERING

MODULE	CSC03A3/CSC3A10 COMPUTER SCIENCE 3A
CAMPUS	AUCKLAND PARK CAMPUS (APK)
ASSESSMENT	JULY 2020

DATE: 2020-07	**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. This is a time restricted open book assessment. Answer **all** the questions in a text processor or on paper, which is scanned and submitted.
2. Write *cleanly* and *legibly* on any handwritten parts (if applicable).
3. This paper consists of 7 pages.
4. Ensure that your submission to **Eve** is *complete* and done *before* the cut-off time.

QUESTION 1

(a) Analyze the code below (which computes the sum of the first n entries of an integer array) and answer the questions that follow. (10)

```
1  public int arrSum(int() A, n){
2  int prod;
3  for(int i=0; i<n; i++)
4    prod += A(i)
5  return prod;
6    }
7  }
```

1. Will the given function return the sum of the array entries? Justify your answer.
2. Give a recursive version of the given function.
3. Draw a recursion trace for your new recursive function with $A = \{2, 4, 6\}$ and $n = 3$.

(b) Using pseudocode, describe how would you go about **adding** an element **after** a given node in a **doubly linked list**? You may use diagrams to support your answer. (5)

Total: 15

QUESTION 2

(a) Which kind of growth best characterizes each of these functions? (Redraw the table in your answer sheet, and put an **X** in the appropriate cells) (6)

	Constant	Logarithmic	Exponential	Polynomial
e^n				
2^{5n}				
$(n+5)^3$				
$\log 4$				
$\log n^2$				
183				

(b) Consider the following function and, using **primitive counting**, express the runtime of this function in Big-Oh notation, along with a justification for your answer. (5)

```
1  public int() prefSum(int() X, int n){
2    int() PartSum = new int(n);
3    for(int i = 0; i< n;i++){
4      PartSum(i) = 0;
5      for(int j = 0; j<=i ;j++){
6        PartSum(i) += X(j);
7        }
8      }
9    return PartSum;
10   }
```

(c) Discuss the **Positional List ADT**, along with the **benefits** and **limitations** of using it. (4)

Total: 15

QUESTION 3

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

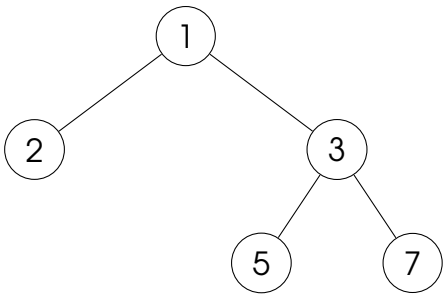
```
1  public interface List<T> {
2    public Node<T> addAfter(Node<T> elem, T item);
3    public Node<T> addFirst(T item);
4    public Node<T> addLast(T item);
5    public T remove(Node<T> elem);
6    public Node<T> search(T elem);
7    public Node<T> first();
8    public boolean isEmpty();
9    public Integer size();
10 }
```

(b) Discuss how a Priority Queue can be used to sort a set of comparable elements. Including the two possible implementations and their performance. (5)

Total: 15

QUESTION 4

(a) Consider the tree below, and answer the questions that follow: (5)



Provide the output if the following traversals are followed:

1. What is the **height** of the tree?
2. What is the **depth** of node with element 2?
3. Is the tree a **proper binary** tree?
4. List the elements in the order of a **inorder traversal** of the tree.

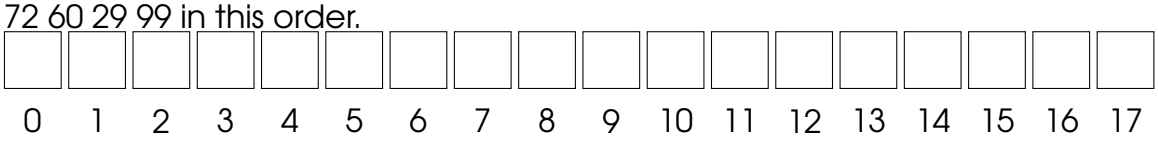
(b) Illustrate the execution of the **bottom-up construction of a heap** on the following sequence. You only need to provide a graphical representation of the heap at each stage in the construction, including any intermediate operations. (10)

(5, 6, 1, 10, 7, 56, 43, 23, 15, 9, 8, 32, 2, 35, 36)

Total: 15

QUESTION 5

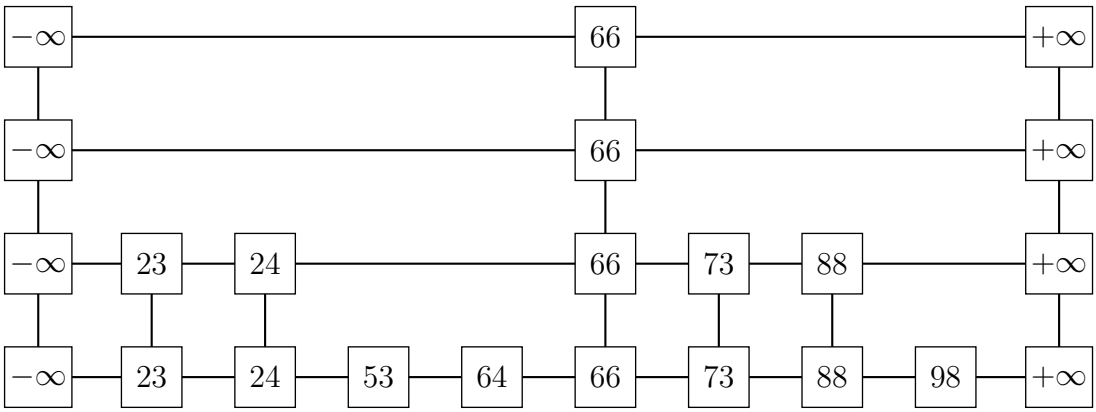
(a) Given a hash function $h(x) = xmod17$ for a hash table that uses **linear probing**, redraw the hash table below and **insert** the keys 84 46 47 22 72 60 29 99 in this order. (8)



(b) What is the **load factor** for the above hash table **after** all the entries have been inserted? (2)

(c) 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**. (4)

(d) Analyse the skip list below and illustrate using diagrams how you would **insert** an entry with a key of 76 and 2 heads coin flips. (6)



Total: 20

QUESTION 6

The World Health Organisation (WHO) is responsible for collating any health-related information captured from around the world and performing analytics relevant to different health disease outbreaks. Discuss **three (3)** data structures that would be the most efficient way to implement this information system, along with its **worst case** run times of its **key** functions, **advantages** and **disadvantages**, and clearly indicate the reasons for your choice.

Total: 15

QUESTION 7

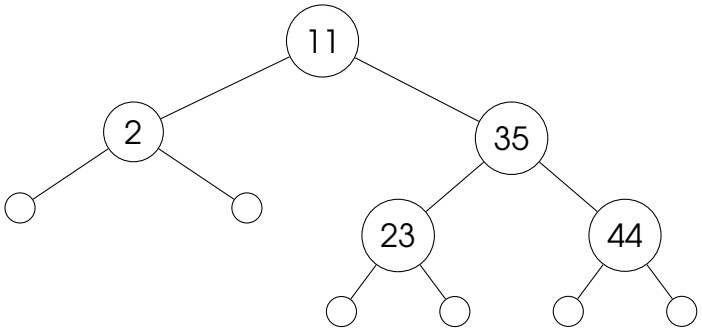
Consider the following AVL tree provided below. Draw the AVL tree state after each of the following operations. If the tree is rebalanced draw the state before and after it being balanced. Removal operations should follow from the tree that resulted from the insertion operations.

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

   9, 8, 40, 35, 43, 18, 3

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

   8, 3



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.

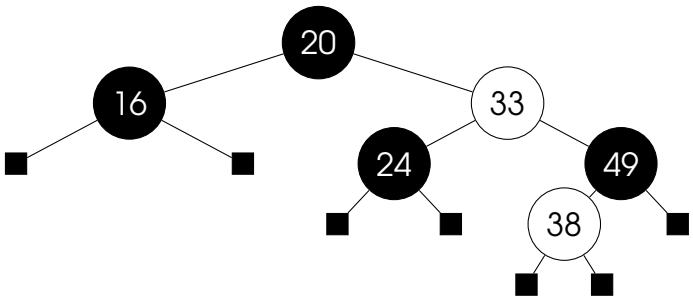
1. Insert nodes that contain the following keys: (inserted one-by-one, in the given order)

   28, 22, 29, 13, 20, 0

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

   33, 28, 49, 29, 24, 22

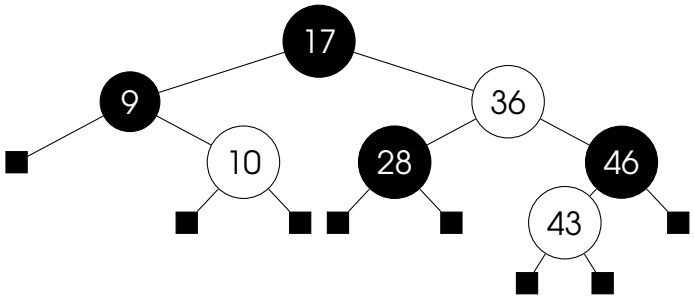
The Red-Black tree is in the current state:



Total: 20

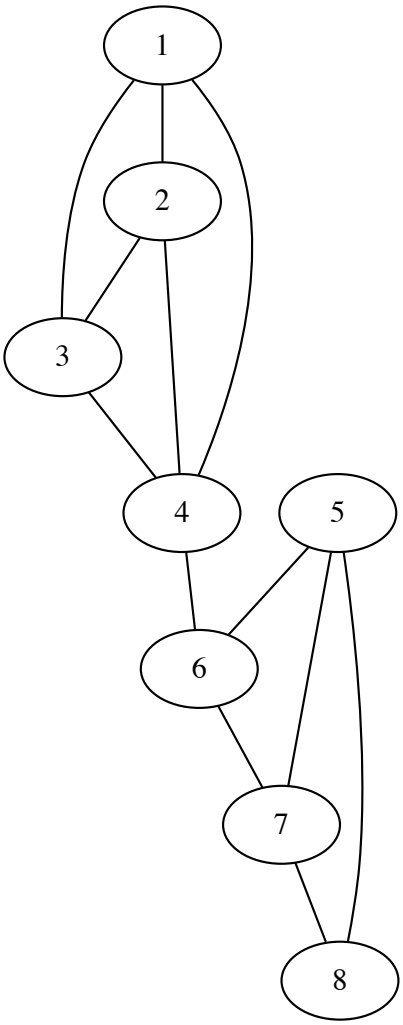
QUESTION 9

(a) Given the Red-Black tree below: (5)



Provide a **(2,4) tree** representation that is equivalent to the above Red-Black Tree.

(b) Analyse the undirected graph representation below and answer the question that follows: (10)



Show how the vertices will be visited if a **Depth First Search (DFS)** is performed, starting at **1**, along with whether you think a DFS or breadth first search (BFS) will reach vertix **8** faster. You may use a figure to support your answer.

(c) Provide a **proof** (by contradiction) for the following theorem: (5)
A digraph admits a topological ordering if and only if it is a Directed Acyclic Graph

Total: 20

— End of paper —