This examination paper consists of THREE sections: Data Structures, Software Engineering and Operating Systems and Computer Networks.

Each section consists of 2 questions
The maximum mark for each section is 50.
The maximum mark for this examination is 150.
This examination consists of 6 printed pages.

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. Do NOT open this examination paper until instructed to do so.

2. Answer ALL questions from the THREE sections.
SECTION A

DATA STRUCTURES

Answer BOTH questions.

1.  (a) A Stack abstract data type (ADT) is implemented in C using appropriate variables and functions.

   (i) Explain the difference between the Stack ADT and the C implementation of the stack. [3 marks]

   (ii) Declare the variables that are needed for the implementation of the stack in C and describe the purpose of EACH. Assume that the stack will store at most 100 integer elements. [4 marks]

   (iii) Write the C code for the push (element) and pop () operations. You must cater for stack overflow and underflow conditions. [8 marks]

(b) The linked list ADT provides an insert operation which inserts new elements at the beginning of the list.

A certain linked list is initially empty. Draw the linked list after the following elements are inserted in the order given (from left to right):

43 38 25

[You must clearly indicate the beginning and ending of the list.] [4 marks]

(c) The Queue ADT provides an enqueue (element) operation and a dequeue () operation. You are given a queue, q, with an unknown number of elements. Using a stack, stk, write an algorithm to reverse the order of the elements in q. Your algorithm must use Stack and Queue ADT operations only. [6 marks]

Total 25 marks

2.  (a) A one-dimensional array contains the marks of 100 students in a certain subject. The marks are not sorted.

Write the C programming code which inputs two integers, lower and upper (where lower is less than upper), and finds and prints the number of marks in the array between lower and upper (inclusive). If no mark is found in the range, print an appropriate error message.

[You do NOT have to input the marks in the array.] [10 marks]
(b) The following 10 integers are stored in a sorted array, \( arr \).

\[
\begin{array}{cccccccccc}
\text{location} & 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\
\text{data} & 7 & 9 & 16 & 22 & 27 & 45 & 50 & 51 & 80 & 91 \\
\end{array}
\]

Describe how a binary search algorithm will search \( arr \) for the following keys:

(i) 16  \hspace{1cm} [6 marks]

(ii) 63  \hspace{1cm} [6 marks]

You must show the portion of the array being searched each time in the loop until the key is found or until it is determined that the key is not present.

(c) The following 10 integers are stored in an array, \( arr \).

\[
\begin{array}{cccccccccc}
\text{location} & 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\
\text{data} & 80 & 91 & 50 & 22 & 27 & 45 & 16 & 51 & 7 & 9 \\
\end{array}
\]

Draw the array after the first, second, and third passes of the selection sort algorithm (i.e., three diagrams in all).  \hspace{1cm} [3 marks]

Total 25 marks
SECTION B
SOFTWARE ENGINEERING

Answer BOTH questions

3. (a) In a university registration system, a student sends an application form containing his/her personal details and the course he/she would like to register for. The university checks a course file to find out if the course is available. If the course is available, the student is enrolled in the course by updating the student file and course file. The university confirms the enrolment by sending a confirmation letter to the student. If the course is unavailable, the student is sent a rejection letter.

Draw a level-0 data flow diagram (first level of decomposition) that depicts the above scenario. [14 marks]

(b) Describe ONE advantage and ONE disadvantage of the evolutionary approach to software development. [4 marks]

(c) Describe FOUR phases in the waterfall approach for software development and state the order in which they will be undertaken. [5 marks]

(d) Discuss ONE reason why it is important to involve end users in the development of a software product. [2 marks]

Total 25 marks

4. (a) A conceptual data model is a representation of an organization’s data. During analysis, it is common to obtain a conceptual data model using a technique known as entity-relationship modelling.

(i) Describe the main components of an entity-relationship model. [6 marks]

(ii) A certain company undertakes software development projects. A project consists of a set of tasks and each task requires various skills such as coding and testing. The company stores the first name, last name, address and telephone number of each employee as well as an employee number to uniquely identify the employee. Each employee has a number of competencies; however, other employees could have similar competencies. Employees may be assigned to only one project being undertaken. However, they can be assigned to one or more tasks based on their competencies.

Draw an entity-relationship model for the above scenario. [13 marks]
(b) A function, *binarySearch*, performs a binary search on an integer array, *arr*, to determine if a certain *key* is present. If *key* is found, *binarySearch* returns the location where the key was found. Otherwise, it returns -1. Its parameters are as follows:

*arr*, an array of integers  
n, the amount of elements in arr, and  
key, the integer being searched for.

Describe THREE tests which can be used to determine if *binarySearch* is working correctly.  
[6 marks]

**SECTION C**

**OPERATING SYSTEMS AND COMPUTER NETWORKS**

**Answer BOTH questions.**

5. (a) Describe the characteristics of EACH of the following transmission media:  

(i) twisted pair  
(ii) fibre optic cables  

[2 marks]  
[2 marks]

(b) A ring network has four computers, but one of the computers has failed. Explain ONE modification to the ring network that will allow the three remaining computers to still transmit data. Use a diagram in your response.  

[4 marks]

(c) With the aid of a diagram, explain the role of a hub in a local area network.  

[3 marks]

(d) With the aid of a diagram, explain how is data communicated in an IEEE802.11a network.  

[6 marks]

(e) Outline the role of a firewall on a computer network.  

[3 marks]

(f) State the role of EACH of layers 1 – 5 of the OSI model for network communication.  

[5 marks]

**Total 25 marks**
6. (a) Using a diagram, explain how a deadlock can occur in an operating system. [4 marks]

(b) Briefly explain how a software interrupt is handled in a system that contains one processor. [4 marks]

(c) List and describe THREE states that a process may be in during execution. [9 marks]

(d) Describe THREE components of a process control block (PCB). [6 marks]

(e) State ONE advantage of a menu interface over a command interface. [2 marks]

Total 25 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.