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 is required to store a set of characters.

   (i) Write code to declare the variables that will be needed by the stack. Assume that the stack size is 1000 characters. [2 marks]

   (ii) Write the function that pushes a character, c, onto the stack. You must cater for stack overflow. [4 marks]

   (iii) Write the function that pops a character from the stack. You must cater for stack underflow. [6 marks]

(b) (i) Using a labelled diagram, explain what is a ‘linked list’. [7 marks]

   (ii) A linked list contains two nodes. With the aid of a diagram in EACH case, explain how a new node can be inserted at the

   a) top of the linked list [3 marks]

   b) bottom of the linked list. [3 marks]

   Total 25 marks

2. (a) The following bubbleSort() function implements the bubble sort algorithm on an array of integers.

   ```c
   void bubbleSort (int a[ ], int numItems)
   {
       int i, j, temp;

       for (i=0; i<numItems-1; i++) {
           for (j=0; j<numItems-i; j++) {
               if (a [j] > a [j+1]) {
                   temp = a [j] ;
                   a [j] = a [j+1];
                   a [j+1] = temp;
               }
           }
       }
   }
   ```

GO ON TO THE NEXT PAGE
(i) Explain the purpose of the outer ‘for’ loop. [2 marks]

(ii) Explain carefully the process that occurs in the inner ‘for’ loop. [3 marks]

(iii) State why the upper limit for j in the inner ‘for’ loop is (numitems – i) and not (numitems). [1 mark]

(iv) The array $a$ contains the following five values:

<table>
<thead>
<tr>
<th>Location</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>8</td>
<td>2</td>
</tr>
</tbody>
</table>

a) Show the contents of the array after each stage during the FIRST pass of the bubble sort. [4 marks]

b) Show the contents of the array at the end of the SECOND and THIRD passes of the bubble sort. [2 marks]

(b) The following 7 integers are stored in an array.

<table>
<thead>
<tr>
<th>Location</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>34</td>
<td>5</td>
<td>10</td>
<td>1</td>
<td>9</td>
<td>23</td>
<td>14</td>
</tr>
</tbody>
</table>

Using the selection sort algorithm, show the contents of the array after each of the first four passes of the sort. [4 marks]

(c) Describe the principles behind the binary search when searching for an item in an array. [6 marks]

(d) The following 16 integers are stored in an array:

<table>
<thead>
<tr>
<th>Location</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>1</td>
<td>5</td>
<td>7</td>
<td>15</td>
<td>19</td>
<td>23</td>
<td>24</td>
<td>28</td>
<td>31</td>
<td>36</td>
<td>54</td>
<td>57</td>
<td>67</td>
<td>72</td>
<td>79</td>
<td>80</td>
</tr>
</tbody>
</table>

(i) How many comparisons does a linear search make before it determines that the value 50 is not present in the array? [1 mark]

(ii) How many comparisons does a binary search make before it determines that the value 50 is not present in the array? Show your working. [2 marks]

Total 25 marks
SECTION B
SOFTWARE ENGINEERING

Answer BOTH questions.

3. (a) (i) Explain what is meant by the term ‘prototyping’. [4 marks]

(ii) Explain how prototyping can be used during the development of a software product. [4 marks]

(iii) State TWO weaknesses of the prototyping approach (that is, evolutionary development). [2 marks]

(b) In a certain hospital, patients are assigned to a single ward where they are treated by one doctor. A ward may have one or more doctors and a doctor can work in one or more wards. There are a number of healthcare assistants who work on each ward and each one may take care of one or more patients in that ward. A patient can also be taken care of by one or more of the healthcare assistants. Each patient has a unique patient ID (primary key). The hospital keeps track of the name of each patient, his/her address, and an emergency contact number. Each patient is administered one or more treatments to deal with his/her specific condition.

Draw an entity-relationship model for the above scenario. Relationships should be named and the cardinality of each relationship should be clearly specified. [9 marks]

(c) Consider the function binarySearch() with the following prototype:

```
int  binarySearch (in[] items, int numItems, int key)
```

The function searches for an integer key in the items array. There are numItems items in the array. If key is found, binarySearch() returns the position where it is found. Otherwise, it returns -1.

Describe THREE tests that should be part of the test plan to unit test the binarySearch() function. [6 marks]

Total 25 marks
4. (a) State THREE traditional methods of determining requirements of a new software system and identify ONE advantage and ONE disadvantage of each method. [9 marks]

(b) A data flow diagram (DFD) typically contains symbols representing external entities, data stores, and processes.

(i) State the purpose of EACH of those symbols when it is used in a DFD. [3 marks]

(ii) For EACH symbol, give a diagram showing how it is used in a DFD. [3 marks]

(iii) A customer sends an order to the order processing system. The system checks if the items ordered are in the inventory. If the items are available, a shipping notice is sent to the warehouse which dispatches the items to the customer and updates the number of items in the inventory. If the items are not available, the order is rejected and returned to the customer.

Draw a level-0 data flow diagram for the scenario above. [6 marks]

(c) Distintuish between ‘functional requirements’ and ‘non-functional requirements’ and give ONE example of EACH type of requirement. [4 marks]

Total 25 marks
SECTION C

OPERATING SYSTEMS AND COMPUTER NETWORKS

Answer BOTH questions.

5. (a) Explain why a peer-to-peer network is generally considered a special case of a client/server network. [4 marks]

(b) Briefly discuss the following THREE issues that should be considered when developing a computer network:

(i) Network security
(ii) Expandability
(iii) Interconnectivity [6 marks]

(c) (i) List, in the correct order, the LAST FIVE layers of the open system interconnection (OSI) model for computer communication. [5 marks]

(ii) For any THREE of the layers listed in (c) (i), describe the role EACH plays in data communication. [6 marks]

(d) A company has FOUR desktop computers and ONE server and wishes to network them. The company has a twisted pair cable as well as a switch. Draw a diagram to illustrate how the devices can be connected. Carefully label all components. [4 marks]

Total 25 marks

6. (a) A user is running a game on a computer. Indicate what situation would cause the game process to move from

(i) ready to running
(ii) ready to blocked. [4 marks]

(b) (i) Outline the function of the process control block (PCB) in an operating system. [1 mark]

(ii) Briefly describe FOUR components of a PCB. [8 marks]

(c) (i) Explain how device drivers function in an operating system. [3 marks]

(ii) State THREE reasons why device drivers may need to be updated. [3 marks]

(d) Batch systems, multi-programming systems, and multi-user systems were significant developments in the history of operating systems. Briefly describe EACH type of operating system. [6 marks]

Total 25 marks

END OF TEST

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