|  | NATIONAL JUNIOR COLLEGE  Mathematics Department  General Certificate of Education Advanced Level  Higher 2 | | | |
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| **COMPUTING**  Paper 1 Written | | | | **9569/01**  **18 September 2020**  **3 hours** |
| Additional Materials: | |  | Pre-printed A4 Answer Booklet | |
| **READ THESE INSTRUCTIONS FIRST**  An answer booklet will be provided with the question paper. You should follow the instructions on the front cover of the answer booklet. If you need additional answer paper ask the invigilator for a continuation booklet.  There are 6 questions totalling 100 marks.  Answer **all** questions.  Approved calculators are allowed.  The number of marks is given in the brackets [ ] at the end of each question or part question. | | | | |
| This document consists of **10** printed pages and 2 blank pages.  NJC Mathematics 2020 **[Turn over** | | | | |

| **1.** | A matrix is a two dimensional object made of rows and columns, having values. The transpose of a matrix **A** is defined as **At** where the the rows and columns of matrix **A** are interchanged. The value at ith row and jth column in **A** will be placed at jth row and ith column in **At**  The following examples illustrate the transpose operations: | | |
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|  | **(a)** | Using a two-dimensional array to represent a matrix, describe a function **Transpose**, in pseudocode to transpose a matrix with m rows and n columns  A two-dimensional array is an array of array. You can assume that the matrix contains only integer values. | [4] |
|  | **(b)** | Design the test cases to verify that your algorithm is correct. You can describe the matrix A using the following syntax:  **A** = [ [1,2,3],[4,5,6],[7,8,9] ] | [3] |
|  | **(c)** | A sparse matrix is a matrix in which more than half of the values in the matrix are zero. For example, the following is a sparse matrix with 4 non-zero values and 12 zero values:    Using two-dimensional arrays to represent very large sparse matrices waste a lot of memory space. In the example above, we need to use 16 memory slots to store 4 values.  Describe a way to represent a sparse matrix so that we can reduce the amount of storage used. | [3] |
|  | **(d)** | Describe an algorithm using pseudocode or structured english to convert a two-dimensional array representing a sparse matrix S, to the representation that you described in 1(c). The sparse matrix S has rows and columns. | [3] |

| **2.** | A program has been written to make use of a sound sensor to capture the noise level of a room and writes the data in a log file every five seconds.  The log file contains 1 row each for every noise sample captured. The format of each row is:  <Date>,<Time>,<Level>  where,  <Date> is in YYYYMMDD format, e.g. 20200510  <Time> is in 24-hour format HHMMSS, e.g. 175010  <Level> is the noise level in dB units, e.g. 23  At the end of the day, another program reads the log file and stores the data as an array of NoiseRecord for further processing. The following describes the structure of the NoiseRecord:  TYPE NoiseRecord  DECLARE Date: STRING  DECLARE Time: STRING  DECLARE Level: INTEGER  ENDTYPE | | | |
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|  | **(a)** | What is the difference between an in-place sorting and a non-in-place sorting algorithm? | [1] |
|  | **(b)** | Describe an in-place sorting function in pseudocode to sort an array of NoiseRecord in descending order of the noise level. The function signature is as follows:  FUNCTION InPSort(Data: ARRAY[1:N] OF NoiseRecord): None  where Data contains all the data in the log file, inserted into an array of size N, of Noise Records. You can assume that Data is passed by reference in the function. | [4] |
|  | **(c)** | Describe an augmented binary search algorithm in pseudocode to find the floor and ceiling of a target value in a sorted array. The target value may or may not exists in the array.  The value of the floor or ceiling is None if they do not exist.  The floor value of is defined as the largest integer less than .  The ceiling value of is defined as the smallest integer greater than .  For example in an array [2,5,9,11],  the floor of the target value 9 is 5 and the ceiling is 11.  The floor of target value 11 is 9 and the ceiling is None.  The floor of target value 1 is None and the ceiling is 2. | [5] |
|  |  |  |  |
|  | **(d)** | Instead of saving the sensor data in a log file, the program can make use of a network to send the data to another program for processing.  Explain how such a communication system could be built. You should describe the components in the system and the characteristics of the communication protocol. Use a diagram if necessary. | [3] |

| **3.** | A linked-list is to be implemented using an array of Node data type.  The following pseudocode describe a Node datatype and the LinkedList datatype  TYPE Node  DECLARE Data: OBJECT  DECLARE Next: INTEGER  ENDTYPE  TYPE LinkedList  DECLARE Buffer : ARRAY[0:N] of Node  DECLARE Start: INTEGER  DECLARE Free: INTEGER  ENDTYPE  The attribute Start points to start of the linked list, a value of -1 represents an empty list.  The attribute Free points to the start of the free nodes list, a value of -1 means no more free nodes available. An empty Node is reresented by its attribute Data set to None. You can assume that the LinkedList is passed as reference in the functions below. | | | |
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|  | **(a)** | Define the following the function:  FUNCTION Initialise LinkedList(L:LinkedList, N) RETURNS None  in pseudocode to initialise the linked list. N is the maximum number of nodes in the linked list. | [3] |
|  | **(b)** | Define the following function  InsertFront(L: LinkedList, node:Node) RETURNS Boolean  in pseudocode to insert a Node to the front of the linked list. The function returns True if insert is successful and False otherwise. | [3] |
|  | **(c)** | The linked list defined above may contain duplicate data, define a function:  Remove(L:LinkedList, data:OBJECT) RETURNS BOOLEAN  in pseudocode, to remove **all** nodes in the LinkedList whose Data attribute equals to data. If one or more nodes is/are removed from the linked list, the function will return TRUE else if data is not found the function will return FALSE. Nodes removed from the linked list must be made available in the free nodes list. | [4] |
|  | **(d)** | In the implementation above, the LinkedList is implemented using a fixed size array to store its nodes. Using an example or use case, explain why this implementation is preferred over using a node-based implementation where the node contains a pointer or reference to the next node. | [2] |

| **4.** | A Cloud Service vendor is providing cloud services to its customers on the Internet. The provider intends to design and implement a web portal front end to allow customers to create, access and monitor the cloud services that they have purchased from the vendor. | | |
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|  | **(a)** | Explain the difference between a Cloud service and a Web service. | [2] |
|  | **(b)** | The Cloud Service vendor intends to provide two type of services, Infrastucture as a Service (IaaS) and Platform as a service (PaaS). Explain the differences between these two services. | [2] |
|  | The Cloud vendor wants to design the web portal to allow the customers to perform the following functions:   * Choose the type of Virtual Machine to create and deploy. A Virtual Machine is a computing resource similar to a physical computer. It allows a customer to install an operating system, install applications and run the applications on the Virtual Machine. There are three types of Virtual Machines the customer can choose to create and deploy:  | Type | Resources | Price (USD) | | --- | --- | --- | | Economy VM | 1 virtual CPU and 4 GB of RAM | $0.005/hour | | Standard VM | 2 virtual CPU and 8 GB of RAM | $0.010/hour | | Performance VM | 4 virtual CPU and 16 GB RAM | $0.020/hour |  * Choose the number of Virtual Disks that they want to attach to the Virtual Machine and the capacity of each Virtual Disks. The prices of the Virtual Disks are as follows:  | Type | Size | Price(USD) Per Disk | | --- | --- | --- | | Small | 256 GB | $10/month | | Medium | 512 GB | $20/month | | Large | 1TB | $40/month |   Note that a Virtual Machine must have at least one Virtual Disk attached to it. A Virtual Disk cannot be purchased without attaching to a Virtual Machine.   * Access the console of the Virtual Machine using a Web interface to perform administrative tasks and to run/stop the Virtual Machine * Instead of choosing to deploy Virtual Machines and Virtual Disks, a customer may instead choose to create one of the following Managed Instances.   A Managed Instance will include all the necessary computing and disk resources to run a web application and its database:   | Instance Type | Resources | Price(USD) | | --- | --- | --- | | Python Web Application with SQLite database | 20 TPS with 1TB database capacity | $0.20/hour | | PHP Web Application with MySQL Database | 20 TPS with 1TB database capacity | $0.25/hour | | ASP.NET Web Application with MS SQL Server | 20 TPS with 1TB database capacity | $0.30/hour |   TPS : Transactions per second   * Access the console of managed instance to upload the web application code, resources and database contents and to run/stop the managed instance. * Before a customer can create any of the resources (Virtual Machines or Managed Instances), he/she needs to register for an account in the web portal.   For both the Virtual machines and Managed instances, the customer can choose to pay a flat fee of $25 per month per Virtual Machine/Managed Instance, to upgrade to a premium service where the vendor will provide a real time back up of the Virtual Machine or Managed Instance image at scheduled intervals. This premium service allowed the customer to perform a full recovery of the Virtual Machine or Managed Instance when needed.  At the end of every month, each customer will be billed based on the resources (Virtual Machines/Disk and Managed Instances) that he/she has consumed. Note that a resource is billed based on the **number of hours** (rounded up to the nearest hour), that it has **run** (execute) for the month. A resource that is created but has 0 hour run time for the month is not billable. | | |
|  | **(c)** | Using an Object Oriented Programming approach, model the entities and their relationship described above using UML Class Diagrams. The design must be able to support all the user functions of the web portal described above.  You must include appropiate attributes and methods for each class. You do not need to include the data type for the attributes but a full detail descriptiion for every attribute and methods is required. | [10] |
|  | **(d)** | Describe and explain how the features of OOP is employed in your desgn. You must include at least two of these features. | [4] |
|  | **(e)** | Customers are concerned about data privacy issues when they store data in the cloud.  Identify two data privacy issues that the Cloud Service vendor needs to address and how they can be mitigated. | [3] |
|  | **(f)** | The cloud vendor wants to provide a NoSQL Database platform in addition to the current Managed Instances services.  State two advantages of using a NoSQL database system over a relational database system in a Web Application. | [2] |

| **5.** | A food delivery web service is to be build that offers food vendors the ability to submit and published their food delivery offerings on a web portal. Customers will need to register for an account before they are able to browse and order food from the different vendors.  A customer can select food items provided by different vendors for each order that he/she made and the system needs to keep track of the total amount payable by each customer per order. Multiple orders per customer can be made in each day. An extenal payment gateway web service will be used to complete the customer's transaction.  A food vendor needs to register and provide the following data fields in the partial web form shown below in order to have their food items published in the web portal.    Food Items offered:   | Item No | Food Item | Description | Price(S$) | | --- | --- | --- | --- | | 1 |  |  |  |     Customers will need to provide the following information when registering for an account in the web portal.   * Name * Delivery Address * Contact Number/   A relational database system is to be used for building the data store used by the web application. | | |
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|  | **(a)** | Draw an Entity-Relationship Diagram (ERD) to describe the data model for the system to be build. | [6] |
|  | **(b)** | Describe the tables for the ERD that you have drawn in **5(a)**, in the form of  TableName(Attribute1: DATATYPE, Attribute2: DATATYPE , ..)  The primary key is indicated by underlying one or more attributes. Foreign keys are indicated by am asterick(\*). | [6] |
|  | **(c)** | When designing a web application, we need to be concern about providing a positive user experience. What is user experience in the context of web application design? How is it related to user interface design? | [3] |
|  | **(d)** | Design and draw the web form for the customer to order food items. Your design must allow the customer to search quickly for the type of food that he/she wishes to order, minimise user inputs and errors and provide a positive use experience. | [4] |
|  | **(e)** | To manage the growth of the data in the database. An archiving solution is needed. Explain how such a solution can be implemented using the current database system. | [2] |

| **6.** | The public Internet is often described as a system of interconnected networks that uses the TCP/IP protocols. | | |
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|  | **(a)** | Explain what is the difference between a Local Area Network (LAN) and a Wide Area Network( WAN). | [2] |
|  | **(b)** | How are the concepts of LAN and WAN apply to the public Internet? | [2] |
|  | **(c)** | What is a protocol ? Explain how the TCP/IP protocols are used on the Internet. | [4] |
|  | **(d)** | A school wants to implement a system for Home-Based Learning (HBL) where students can submit their assignments in digital form, from their home, to their teachers for feedback and marking. The school wants the assignments to be submitted and stored on a server connected to a LAN in the school premise. The teachers must also be able to access their students' submissions from their home.  Describe with the help of a network diagram, how such a system can be implemented. Describe also the network devices, services and applications that are needed to implement the solution. | [4] |
|  | **(e)** | Describe the security features that need to be implemented in the use case described in question **6(d)** | [4] |
|  | **(f)** | The school also wants the server to have a unique DNS name for the students and teachers to access. Explain what is a DNS name and how can we obtain and assign a DNS name to the file server. | [2] |

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