Diploma Programme
Programme du diplôme
Programa del Diploma

Computer science
Standard level
Paper 2

Thursday 5 May 2016 (afternoon)

1 hour

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all of the questions from one of the options.
- The maximum mark for this examination paper is **[45 marks]**.

Option	Questions
Option A — Databases	1 – 3
Option B — Modelling and simulation	4 – 6
Option C — Web science	7 – 9
Option D — Object-oriented programming	10 – 12

14 pages

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Option A — Databases

1. *CrossCountryXL* is a transport company that delivers items from different **retailers**.
    Each **retailer** has many **suppliers**.

    (a)   Construct the entity-relationship diagram for this scenario.   [3]

    CrossCountryXL constructs a relational database to store data about the items that suppliers
    supply to retailers. The following tables form part of this database.

    •   The **SUPPLIER** table contains contact details for each supplier. Each supplier supplies
        only one item

    •   The **SUPPLY** table identifies the supplier's item. The attribute "Nature_Of_Goods" takes a
        value of "P" for perishable or "NP" for non-perishable items

    •   The **ITEM** table contains the item details.

    Some of the data in these tables is shown below and on the following page. The underlined
    attribute indicates the primary key in each table.

    SUPPLIER

Supplier_ID	Name	Email_ID	Location
98769171	Joyce	joyce@123.com	Paris
34567890	Ahmed	ahmed@rex.com	Seville
54959299	John	john@fish.com	Rotterdam
32010309	George	george@abcd.com	Frankfurt
45908919	Ram	ram@tech.com	London
……	……	……	……

    SUPPLY

Supplier_ID	Item_ID	Nature_Of_Goods
98769171	X391	NP
34567890	B453	P
54959299	X892	P
32010309	X903	NP
45908919	B670	P
……	……	……

(Option A continues on the following page)

(Option A, question 1 continued)

ITEM

Item_ID	Item_Name	Description	Quantity (in cartons)
B311	Oranges	Citrus fruit	190
B432	Apples	Seasonal fruit	60
X543	Watches	Accessories	75
B566	Pears	Seasonal fruit	90
B767	Spinach	Leafy vegetable	110
B202	Bags	Utilities	180
X321	Wallets	Utilities	201
B876	Lamps	Equipment	103
B213	Tomatoes	Organic vegetable	167
……	……	……	……

(b)   The Supplier_ID "34567890", in the SUPPLY table, is updated to become "54959299".

        Outline, with respect to the primary key, how the referential integrity constraint is
        violated in the relation SUPPLY.   [2]

(c)   For the data in the tables on pages 2 and 3, state the output of the following queries.

        (i)   Select Item_Name from ITEM where Quantity > 150.   [1]

        (ii)   Select Supplier_ID from SUPPLY where Nature_Of_Goods='P'.   [1]

(d)   Identify the steps to create a query to find the names of suppliers who supply perishable
        goods.   [4]

CrossCountryXL needs to ensure supplier data is not lost at any time.

(e)   Outline **two** measures that *CrossCountryXL* should take in order to be able to restore
        supplier data if it is lost.   [4]

(Option A continues on the following page)

(Option A continued)

2.   An online School Management System allows restricted access for the parents of students. Each parent is able to check their child's attendance and subject grades.

      (a)   (i)   Define the term *schema*.   [1]

             (ii)   With reference to this School Management System, distinguish between data and information.   [2]

All teachers at the school are able to access and update the database in the School Management System.

      (b)   (i)   Describe a problem which could arise due to concurrency in this scenario.   [2]

             (ii)   Explain which of the ACID properties of a database prevent concurrency problems.   [4]

Student records are regularly inserted and grades are permanently stored in the system. Occasionally, while read or write operations are taking place, a system error occurs that prevents the transaction from being completed. Such a situation demands a *rollback*.

      (c)   With a suitable example, outline rollback as a transaction operation in this School Management System.   [3]

      (d)   Explain what is meant by durability, as a transaction property.   [2]

(Option A continues on the following page)

(Option A continued)

3.   A science research firm stores all of its data in a large central database, and employs a database administrator to maintain it.

(a)   Suggest **two** measures that the database administrator should take to prevent personnel from misusing the database systems.   [2]

(b)   State **one** implication to the science research firm's research as a result of storing its data in this way.   [1]

Employees in the firm have their details stored in the database. The employees are categorized based on the departments in which they work. Part of the database is shown below.

EMP_DEPT

EmpName	SSN	DOB	Salary	Address	DeptNo	DeptName	DM_SSN
James	9955	1940-11-10	35 000	731, Stone Road, AZ	1	Admin	455
Joy	6611	1969-03-29	20 000	890, Fire Drive, AZ	4	Research	210
Jennifer	7632	1940-06-20	43 000	291, Cherry Hill, AZ	5	Design	728
Harry	6641	1974-06-01	36 000	292, Orchard Drive, AZ	1	Admin	455
Marie	8752	1967-09-02	49 000	234, Vine Street, AZ	4	Research	210
……	……	……	……	……	……	……	……

EmpName: the name of the employee
SSN: their social security number
DOB: their date of birth
DeptNo: their department number
DeptName: their department name
DM_SSN: the social security number of the employees' department manager.

Employees of the science research firm are protected by the Data Protection Act.

(c)   With specific reference to the data stored, outline **two** methods to ensure the privacy of the employee's data in the research firm's database.   [4]

Data in the EMP_DEPT relation is used for data mining on a large scale.

(d)   Explain the difference between data matching and data mining.   [4]

Database normalization is a way of organizing the fields and tables of a relational database.

(e)   (i)   State **two** advantages of normalizing the database to 3rd Normal Form (3NF).   [2]

(ii)   Construct the relation EMP_DEPT to 3NF, limited to the information explicitly visible in the table above.   [3]

End of Option A

Option B — Modelling and simulation

4. An estate agent calculates the estimated selling price of properties within a town, according to the following criteria:

- the size (in square metres) of the property
- whether the property is a house or an apartment
- the district in which the property is located (the town is divided into districts 1, 2, 3 and 4)
- the condition of the property, rated "very good", "good", "medium", "poor" or "very poor".

A mathematical model is set up to store the above variables for each property that is for sale, and to calculate the estimated selling price.

(a) Outline, with an example, a suitable way of representing each of the variables that is needed to store the information in a spreadsheet. [4]

The rules for the model are as follows:

- initial value of an apartment = $2000 per square metre
- initial value of a house = $2300 per square metre
- a multiplier is then applied according to the district in which the property is located: 1.25, 1.00, 0.95 or 0.90, where the most popular district (district 1) has a multiplier of 1.25 and the least popular district (district 4) has a multiplier of 0.90
- another multiplier is applied, based on the condition of the property. For example, a house in good condition has a multiplier of 1.00.

(b) Using a spreadsheet, construct a model which uses the values of the variables from part (a) to find the appropriate multipliers and calculate the estimated price for a property. [6]

The estate agent uses the spreadsheet to calculate the estimated price and to store the date on which the property was first for sale. When a property is sold the final selling price and the date sold are recorded. Properties are not always sold at the price estimated by the estate agent.

(c) Suggest how the data from sold properties could be used to test and change the rules of the model. [3]

(d) Suggest ways in which the estate agent could use the model to identify the characteristics that make a property difficult to sell. [4]

(Option B continues on the following page)

(Option B continued)

5.   A railway company has ticket machines and manually operated ticket offices in all of its stations. There are two types of ticket machine:

Type 1: where tickets which have been purchased online can be collected.
Type 2: where tickets can be bought by selecting a journey and date.

The ticket offices are manned by employees who sell and renew season tickets and can also carry out the same functions as the Type 2 ticket machines.

The distribution of machines and ticket offices at each station causes some problems.

Customers complain that:
•   the ticket offices are often closed when they are needed.
•   during busy periods they have to wait too long at the ticket machines and sometimes miss trains that they have already booked online.

The railway company decides to run computer simulations to compare different ways of organizing the numbers and types of machines and ticket offices in one particular station.

(a)   Explain the difference between a model and a simulation in relation to this scenario.   [4]

(b)   (i)   Identify the data that is needed to run the simulations.   [2]

         (ii)   Outline an efficient method of data collection for this scenario.   [2]

(c)   Outline how different combinations of machines and ticket offices can be simulated using the data collected.   [2]

(d)   Suggest **one** criterion which could be used to compare the results of the simulations.   [2]

(e)   Discuss the validity of using the simulations of this station to install ticket systems in other stations.   [4]

(Option B continues on the following page)

(Option B continued)

6. Emergency helicopter pilots are likely to encounter a variety of unpredictable and dangerous situations and need extensive training. One training method is for pilots to be trained by flying with an experienced pilot for a period of time. An alternative method is to use simulation software.

    (a) Outline **one** advantage and **one** disadvantage of training pilots with simulation software as opposed to working with an experienced pilot.   [4]

    (b) Outline the hardware and software required for the simulation in this scenario.   [2]

    (c) Outline the need for 3D visualization in this scenario.   [3]

    (d) Describe how the representation of the image stored in memory can be visualized in 3D.   [3]

End of Option B

Option C — Web science

7.   HTTPS is not a distinct protocol, but makes specific use of a combination of two separate protocols.

    (a)   (i)   Identify these two protocols.   [2]

          (ii)   Outline their functions.   [4]

    (b)   Outline the interaction between a user, a web browser and a domain name server when accessing sites on the internet.   [4]

The following PHP script accesses the database "library.db", using data gathered from a web form.

```php
<?php
$con=mysqli_connect("library.db");
$result = mysqli_query($con,"SELECT * FROM Books WHERE Author =
$_POST["author"]"); echo "<table border='1'>
<tr>
<th>FirstName</th>
<th>LastName</th>
</tr>";
while($row = mysqli_fetch_array($result))
{ echo "<tr>";
echo "<td>" . $row['FirstName'] . "</td>";
echo "<td>" . $row['LastName'] . "</td>";
echo "</tr>";
}
echo "</table>"; mysqli_close($con);
?>
```

    (c)   (i)   Describe the processing that takes place when the form that was sent from the client is received by the web server.   [4]

          Scripts can be created on both the client-side and server-side.

          (ii)   Explain, giving **two** reasons, why the use of server-side scripting promotes security when retrieving content from databases.   [4]

(Option C continues on the following page)

(Option C continued)

8. (a) Define the term *black hat search engine optimization*. [2]

In an attempt to rank more highly with search engines, a web developer has included the following text on his web page:

"We have the best apple pies! Try our apple pies as they are delicious. We have apple pies like your mother makes. Our apple pies are made from the best apples. Try our special offer for apple pies."

(b) With reference to the specific search engine optimization technique being used here, discuss **two** possible consequences from the inclusion of this text on the web developer's web page. [5]

Many search engines examine the pages that **link to** a particular site and use this information when indexing this site.

(c) Outline, with an example, how the content of these linking pages will affect the ranking given to the site. [3]

9. The *Internet of Things* (IoT) is a term that describes the interconnectivity made possible by the widespread use of ubiquitous computing.

(a) (i) Define the term *ubiquitous computing*. [1]

The IoT predicts the widespread use of uniquely identifiable devices which will be accessible through the internet.

(ii) Suggest whether the characteristics of the internet protocol (IP) will be able to handle this predicted increase in use. [2]

The increase in the number and type of devices that can be accessed through the internet will have many possible advantages.

(iii) Explain **one** way in which this use of ubiquitous computing might help a car rental company manage its business. [4]

The availability of information on the web has led to increased opportunities for plagiarism. However, there are now several web sites that perform text analysis in order to establish authenticity. Various techniques are used to establish the degree of authenticity.

(b) Describe **two** of the limitations of the services offered by these web sites. [4]

A major country is proposing allowing deals between commercial companies and ISPs to prioritize delivery of their web traffic. This has provoked an intense debate between those who support net neutrality, which is based on the principles of a democratic web, and those who consider these deals as a valid business proposition.

(c) By examining the concepts of net neutrality and by making use of examples, discuss the merits of this proposal. [6]

End of Option C

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Option D — Object-oriented programming

A hotel has 100 rooms and uses an OOP program to deal with allocating the rooms to clients when they arrive at the hotel. The program contains a `Client` class and a `Room` class. A user-defined `Dates` class is also used. Part of the `Client` class and `Dates` class are shown below.

```
public class Client
{ private int customerID;
  private String name;
  private Dates arrive;
  private Dates leave;
  private Room bedroom;

  public Client(int id, String c, Dates dateIn, Dates dateOut, Room r)
  { setCustomerID(id);
    setName(c);
    setArrive(dateIn);
    setLeave(dateOut);
    setBedroom(r);
  }
  public void setCustomerID(int id) {customerID = id;}
  public void setName(String c) {name = c;}
  public void setArrive(Dates dateIn) {arrive = dateIn;}
  public void setLeave(Dates dateOut) {leave = dateOut;}
  public void setBedroom(Room r) {bedroom = r;}

  public int getCustomerID() {return customerID;}
  public String getName() {return name;}
  public Dates getArrive() {return arrive;}
  public Dates getLeave() {return leave;}
  public Room getBedroom() {return bedroom;}

  public void bill()
  {... // method that calculates the bill for this client
  }
}

public class Dates
{ private int day;
  private int month;
  private int year;

  public Dates(int day, int month, int year)
  { this.day = day;
    this.month = month;
    this.year = year;
  }
  public int getDay() {return day;}
  public int getMonth() {return month;}
  public int getYear() {return year;}
  public static int StayDays(Dates x, Dates y)
  {... // method that calculates the number of nights between x and y
  }
}
```

(Option D continues on the following page)

(Option D continued)

The `Room` class contains the following variables.

- `roomNumber`   a value that identifies the room
- `beds`   the number of beds in the room
- `price`   the price of the room, per night
- `empty`   indicating whether or not the room is occupied.

10. (a) State the relationship between `Client` and `Room`. [1]

(b) Construct a UML diagram for the `Room` class. [4]

(c) Outline **one** advantage of using a class to represent the dates. [2]

The `Room` objects are held in the array `allRooms[]` in ascending order of `roomNumber`.
For example, the object for room 5 is held in `allRooms[4]`.

(d) Construct a method, `findRooms()`, that searches `allRooms[]` and returns the
`roomNumber` of all empty rooms that have two beds. [6]

(e) Construct the method, `bill()`, in the `Client` class to calculate and output a bill for a
client based on the price of the room per night and the number of nights spent in the hotel.
The bill should include:
- the client's name
- the room number
- the date that they arrived
- the date that they are leaving
- the total number of nights they stayed
- the total cost. [8]

(Option D continues on the following page)

(Option D continued)

11. The hotel accepts group bookings where many clients, such as tour groups, can be allocated rooms on arrival. The Group class contains the name of the group, the number of rooms used by the group and a method `bill()` that calculates the total bill for the group.

    Part of the Group class is shown below.

    ```
    public class Group
    {
      private String name; // name of group
      private int number;  // number of rooms allocated to the group

      public Group(String name, int number)
      {
        this.name = name;
        this.number = number;
      }

      public String getName() {return name;}
      public int getNumber() {return number;}

      int[] gRooms = new int[number];
      // array to hold room numbers allocated to the group

      public double bill(int[] gRooms)
      {... // method that calculates the bill for the group
      }
    }
    ```

    The GClient class represents a client who is part of a group. It inherits all the class members of the Client class and also stores the name of the group.

    (a) Construct the GClient class.   [7]

    (b) With reference to the objects, methods and parameters, describe the process of allocating rooms when a tour group called "Happy Travellers" arrives at the hotel and is allocated 15 rooms, each of which has two beds.   [6]

    (c) Construct the method, `bill(int[] gRooms)`, to calculate and output the total cost of the group's rooms for one day.   [5]

12. The company wishes to update this OOP program and sell it to other hotels. They hire a programmer to make appropriate changes to the program.

    (a) Outline the responsibilities that the programmer has when updating the program.   [2]

    (b) Discuss the features of modern programming languages that enable the program to be sold in other countries.   [4]

End of Option D