Diploma Programme
Programme du diplôme
Programa del Diploma

**Computer science
Standard level
Paper 2**

Wednesday 20 May 2015 (morning)

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

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Option A — Databases

1.   A tourist has booked a double room, non-smoking, at the Overlook Hotel. The tourist used
     an online booking service called Best Fare that compares offers from different hotels.

     Best Fare confirms the transaction by communicating only the booking code 3EP9RE to
     the tourist. The tourist later receives an email from the hotel, with further details.

     (a)   Outline the difference between data and information, in relation to the booking code.   [2]

     (b)   Define the term *database transaction*.   [2]

     (c)   Describe the use of transactions to maintain data consistency.   [3]

     (d)   Explain what is meant by isolation in the transaction described above.   [2]

     (e)   Explain the benefits offered by data sharing in databases, for **two** of the stakeholders
           in this scenario.   [6]

2.   An information system is used to manage the pharmacy of a hospital. It includes the
     database that contains the availability of different types of medicine. Data on patients who
     are taking specific medicines are also stored in the database.

     The database can be used by the database administrator, internal hospital staff and also the
     staff of nearby hospitals.

     (a)   Outline the role of a database administrator, in the hospital.   [2]

     (b)   Outline what is meant by a data dictionary.   [2]

     (c)   Discuss why the view of the database is different for different users in this scenario.   [6]

(Option A continues on the following page)

(Option A continued)

3. The following data represent orders for shelving units. Each order specifies:
    - an order number
    - an order date
    - a product code
    - a description
    - a quantity
    - unit prices
    - a total price.

    The shelving units are available in wood or plastic, in small, medium or large size. There is also an extra-strong shelving unit, made from steel, which is only available in the large size.

OrderNr	OrderDate	ProductCode	Description	Quantity	UnitPrice	TotalPrice
100	10/10/2014	WS WL PS	Wood, Small Wood, Large Plastic, Small	1 1 2	30.00 80.00 40.00	 190.00
101	11/10/2014	PS PM	Plastic, Small Plastic, Medium	1 2	40.00 75.00	 190.00
102	11/10/2014	XX	Extra-strong, Large	3	200.00	 600.00

(a) Outline why this table is **not** in 1st Normal Form (1NF).   [3]

(b) State **three** advantages of normalization.   [3]

(c) State, with a reason, whether "TotalPrice" alone can be a primary key.   [2]

(d) Suggest a way to ensure that "Description" contains atomic values in a table.   [2]

(e) Construct the table(s) in 1st Normal Form (1NF), for the given data.   [3]

(f) State the condition that attributes must meet, with respect to composite primary keys,
     to produce 2nd Normal Form (2NF).   [2]

(g) Using your answer to part (e), construct the table(s) in 3rd Normal Form (3NF).   [5]

End of Option A

Option B — Modelling and simulation

4. A specific type of fish lives and breeds in a lake. It is important that the fish population in the lake has stability and does not decrease too much.

Each year people who want to fish from the lake are issued licences under the following conditions.

- The estimated number of fish in the lake has **not** fallen by more than 5% over the last five years.
- The estimated average length of fish is **greater** than 20 cm.

These estimates are based on samples taken throughout the year from random sections of the lake.

(a) Outline the steps involved in combining and recording the results from five separate samples taken from the lake in one year. [4]

(b) Identify the variables needed to create a model that can be used to decide whether or not licences should be issued. [2]

(c) Explain how the model from part (b) could be constructed and used. You should make reference to specific software with which you are familiar. [3]

People who want to fish have complained that the model is not working and that often they are denied licences unnecessarily. At the same time, a protest group is complaining that too many fish are being taken out of the lake.

(d) Discuss how the model may be tested and corrected if necessary. [6]

5. Climate is cyclical as well as being affected by other factors.

(a) Identify **four** factors that could be used to define the current weather in a particular area on a particular day. [2]

(b) Suggest how values for these factors could be presented to show weather patterns over one year. [3]

One aspect of climate change is displacement; for example, summer weather beginning later than in previous years.

(c) Outline how a computer system could be used to detect displacement trends in climate change. [4]

(d) Discuss the advantages and disadvantages of using the results from a computer simulation to predict long term climate change. [6]

(Option B continues on the following page)

(Option B continued)

6. Computer gaming, whether alone or as part of an online group, is increasingly popular. With realistic graphics, players become involved in simulated virtual worlds.

(a) Define the term *visualization*. [2]

(b) With reference to lighting and rendering, outline how an image held in memory can be shown on screen as a realistic 3D image. [5]

(c) Outline the specifications of the software and hardware required to run a successful online game simulation on a home computer. [3]

(d) Discuss the advantages and disadvantages of participating in a simulated world of online gaming. [5]

End of Option B

Option C — Web science

7. (a) Outline the principal difference between HTML and HTTP. [2]

Consider the section of XML code shown below:

```
<bird>
  <name>Eagle Owl</name>
  <species>Bubo bubo</species>
  <description>An owl the size of an eagle</description>
  <habitat>Forests</habitat>
</bird>
```

(b) Identify **one** similarity between HTML and XML. [1]

One of the characteristics of XML code is its ability to describe data.

(c) By making direct reference to the XML code above, outline **one** way in which this characteristic is shown. [2]

The XML code, above, is sent via the HTTP protocol from a client to a server where it is used to update a database.

(d) Describe how the structure of XML code allows data to be used to update a database. [2]

When a user enters a URL into the search bar of the browser the URL will normally be sent to a domain name server.

(e) Identify the **two** possible actions that this domain name server will then take. [2]

Protocols and standards are essential features of the successful operation and development of the web.

(f) (i) Distinguish between the terms protocol and standard. [2]

(ii) With specific references to **one** protocol and **one** standard, discuss the consequences if they did not exist. [6]

**(Option C continues on the following page)**

(Option C continued)

8.   The PageRank algorithm is used by Google's search engine.

(a)   Identify the specific purpose of the PageRank algorithm.   [2]

A page has more chance of being listed on the first page of a Google search if it has many links coming into it from other websites.

Page A links to Page B as shown in the diagram below. The arrows represent some of the links from the two pages.
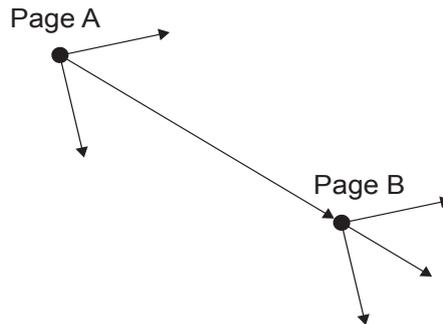
Page A

Page B

(b)   Identify **two** factors that will determine the effect that the link from Page A will have on the PageRank of Page B.   [2]

(c)   Describe why the use of meta-tags might not always return the results expected by a search query.   [2]

(d)   Explain, with the use of **three** examples, how black hat search engine optimization tries to manipulate page ranking.   [6]

9.   (a)   Identify **two** different types of file which, if compressed, could make use of a lossy compression algorithm.   [2]

(b)   With the use of examples, outline the difference between interoperability and open standards.   [4]

The technologies associated with Web 2.0 have often been described as leading to the emergence of social networking.

(c)   Describe **two** different features, associated with these new technologies, which have contributed to this emergence.   [4]

A small company is deciding whether to make use of a private cloud service for storing their customer data instead of storing it on their own server.

(d)   Discuss the security issues that will affect the company's decision.   [6]

End of Option C

Option D — Object-oriented programming

A library in a college loans books to students.

The current book borrowing system, which was developed years ago, is prone to error. You are a member of the new program development team which has decided to develop a system using an object-oriented programming (OOP) approach. The team will be divided into small sub-groups.

The program development team is aware of the following user requirements.

- Certain books are classified as **short term** and can only be borrowed for 5 days. Other books are classified as **long term** and can be borrowed for 30 days.
- Fines are charged at a rate of $1.50 for each day that a short term book is overdue.
- Fines are charged at a rate of 10 cents for each day that a long term book is overdue.
- If the overdue period exceeds 4 days for any short term loan book students are not allowed to borrow any more books and their borrowing rights are suspended; this does not apply for long term book loans.
- Students can borrow a total of 10 books.

10. (a) Outline **two** advantages that the programming team should expect from using an OOP approach. [4]

(b) Explain **two** ethical issues which should be taken into account when working on the project. [4]

(Option D continues on the following page)

(Option D, question 10 continued)

Following some analysis, the team determined that the Loan and Student classes will be used. Part of the Student class is shown below.

```java
import java.util.*;
public class Student
{
  private int studentID;
  private String studentName;
  private Loan[] booksBorrowed = new Loan[10];
  private int numBooks = 0;
  public Student(int studentID, String studentName)
  {
    this.studentID=studentID;
    this.studentName=studentName;
  }
  public Loan getLoan (int x)
  {
    return this.booksBorrowed[x];
  }
  public void addLoan(Loan book)
  {
    this.booksBorrowed[numBooks] = book;
    numBooks++;
  }
  public int getStudentID()
  {
    return this.studentID;
  }
  public String getStudentName()
  {
    return this.studentName;
  }
}
```

When creating objects, encapsulation is an important design consideration.

(c)   Outline, with direct reference to the `Student` class, how security can be enhanced by using encapsulation.   [3]

To use the `Student` class in a program an object has to be created or instantiated.

(d)   Construct a statement to create a `Student` object for a student with an ID of 93003 and a name of "Smith".   [2]

(Option D continues on the following page)

(Option D, question 10 continued)

The basic `Loan` class is shown below. Every time a book is borrowed, an instance of the `Loan` class is created. In the `Student` class, the books borrowed by a single student are stored in an array called `booksBorrowed`.

```java
import java.util.*;
public class Loan
{
  private int bookID;
  private String bookTitle;
  private Date d;
  static int numBooksLoaned = 0;
  public Loan(int bookID, String bookTitle)
  {
    this.bookID = bookID;
    this.bookTitle = bookTitle;
    this.d = new Date(); //set date borrowed
    numBooksLoaned = numBooksLoaned +1;
  }
  public int getBookID()
  {
    return this.bookID;
  }
  public String getBookTitle()
  {
    return this.bookTitle;
  }
  public Date getDate()
  {
    return this.d;
  }
  public void setBookID(int id)
  {
    this.bookID = id;
  }
  public void setBookTitle(String title)
  {
    this.bookTitle = title;
  }
  public void setDate(Date d)
  {
    this.d = d;
  }
}
```

Note the use of the keyword static in the statement `static int numBooksLoaned = 0` and that this term is not used in the other variable declarations.

(e)   Explain the use of the term static for the variable `numBooksLoaned` in the `Loan` class.   [3]

(f)   Construct the code needed to add a loan with a book ID of 212000 and a book title of "The Stars" to a `Student` object, `ST`.   [3]

(Option D continues on the following page)

(Option D continued)

11. In order to store each `Student` object the team has decided to use the `borrowers` array of type `Student`. The team has also decided to use the student's ID as the index into the array. For example, a `Student` object with a student ID of 1111 would have its reference stored in position 1111 of the array.

Consider the code fragment below which would appear in a suitably constructed `main` class.

```java
public static void main(String[] args)
{
    Student temp;
    Student[] borrowers = new Student[100000];

    temp = new Student(93001, "Jones");
    temp.addLoan(new Loan(210001,"The Sky"));
    borrowers[93001] = temp;

    temp = new Student(3012, "Zang");
    temp.addLoan(new Loan(210121, "The Animals"));
    borrowers[3012] = temp;

    borrowers[93001].addLoan(new Loan(210002, "The Spooks"));

    temp = new Student(93002, "Nguyen");
    temp.addLoan(new Loan(210011, "The Ocean"));
    borrowers[93002] = temp;

    System.out.println(borrowers[93001].getStudentName());
    System.out.println(borrowers[93001].getLoan(1).getBookTitle());
    System.out.println(borrowers[3012].getLoan(0).getBookTitle());
}
```

(a) Determine the output from the following statements.

   (i)   `System.out.println(borrowers[93001].getStudentName());`   [1]

   (ii) `System.out.println(borrowers[93001].getLoan(1).getBookTitle());`   [1]

   (iii) `System.out.println(borrowers[3012].getLoan(0).getBookTitle());`   [1]

The librarian requires a display of the student name, the titles of the books and the dates that they were borrowed, corresponding to a specific student ID.

(b) Construct the method `showDetails()` that could be used in the `main` class, which accepts a student ID as a parameter, and then uses this to access the appropriate `Student` object producing the desired output as indicated above.   [7]

(c) State **three** aspects of the user requirements that are not addressed by the current design.   [3]

(d) Describe a modification to the `Student` class that would address **one** of the missing requirements.   [2]

(Option D continues on the following page)

(Option D continued)

12. The team has decided to use inheritance in its design.

    (a)   Describe **one** benefit that inheritance brings to OOP. [2]

Two sub-classes will be created: `shortTerm` and `longTerm`.

    (b)   State **two** additional attributes that each `shortTerm` object should have. [2]

    (c)   Construct a suitable UML diagram showing the relationships between the `Student` class, the `Loan` superclass and the two sub-classes. **Note:** there is no need to include the attributes or methods of each class. [4]

    (d)   Outline, using an OOP technique, how the total number of books on loan could be displayed without processing the `borrowers` array. [3]

End of Option D