Diploma Programme
Programme du diplôme
Programa del Diploma

Computer science
Standard level
Paper 2

Monday 7 November 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 – 14

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Option A — Databases

1. A college maintains a database to store information about the courses that it offers, as shown in the table below.

CourseTable

CourseID	Course_Name	Duration *(Hours)*	Cost
CS1200	Word Processing	10	30.00
CS1234	Databases	20	60.00
CS1201	Java Programming	105	150.00
CS5201	Java Programming – Advanced	50	90.00
CS1280	Python Programming	75	130.00
CS1331	C Programming	100	180.00
CS1209	Spreadsheets	20	30.00
…	…	…	…

(a) Outline the difference between data and information. [2]

(b) Suggest an appropriate data type for each attribute in this database. [3]

(c) Explain the role of data validation. [2]

(d) State a validation check which might be helpful when entering a

(i) `CourseID`; [1]

(ii) `Cost`. [1]

(e) (i) Identify the steps in a query, that could be constructed to produce a list of the names of courses with a duration between 40 and 80 hours. [3]

(ii) Describe **one** function that is required to be performed on databases, other than the query function. [2]

2. The database schema is the definition that describes the entire configuration of a database.

(a) Outline the characteristics of the **three** levels of the schema. [6]

(b) (i) Explain **two** responsibilities of a database administrator. [4]

(ii) Explain, with an example, how the database administrator would use a data definition language. [3]

(c) Identify **four** consequences of poor data modelling in the design of a database. [4]

(Option A continues on the following page)

(Option A continued)

3. Normalization can be described as a process of taking data from a given problem and designing it to a set of relations while ensuring *data integrity* and reducing *data redundancy*.

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

(b) Outline what is meant by referential integrity of data. [2]

The following table, **College**, holds information about students, subjects and examination grades.

College

StudentID	Name	Gender	Subject	ExamGrade
CA3214	Ann Stern	F	Biology	5
CA3214	Ann Stern	F	Mathematics	5
CA3214	Ann Stern	F	Chemistry	3
SE1123	Mia Mann	F	Biology	7
FR2345	Joseph Hu	M	Computer Science	7
FR2345	Joseph Hu	M	Biology	6
FR2345	Joseph Hu	M	Physics	5
WR6543	Rea Kohn	F	Mathematics	4
…	…	…	…	…

(c) Explain the steps that would have to be taken in order to hold this data in a relational database in 2nd Normal Form (2NF). You should include an example of the 2NF form in your answer. [6]

(d) Describe **two** ways that a database management system (DBMS) can be used to promote data security. [4]

End of Option A

Option B — Modelling and simulation

4. The population of rare tropical insects on an island follows a geometric model such that the population multiplies by k from one month to the next.

For example if $k = 2$ the population would double each month.

This situation can be expressed as either $P_{n+1} = kP_n$ **or** $P_n = P_0 k^n$.

P_0 is the initial population.
k is a constant.
P_n is the population after n months.

(a) For a value of $k = 3$ and an initial population of 100, calculate the population after two months, P_2. [2]

(b) With the aid of a diagram, outline the way in which a spreadsheet could be used to estimate the size of the population after each of the first 10 months. [3]

Each month it is estimated that only 40 % of insects survive due to various circumstances such as climate and lack of nutrition. This is known as a **constant survival rate** of 0.4.

(c) Outline how this factor could be built into your spreadsheet, stating any assumptions that you make. [2]

Another model assumes a **changing survival rate** and recalculates the rate for each month using the following formula:

$x_{n+1} = rx_n (1 - x_n)$ where x_n is the survival rate in month n. $(0 < x_n < 1)$
r is a constant.

For example, using $r = 3$ and a survival rate of 0.4 in the first month, the survival rate for the second month would be:

$x_2 = rx_1 (1 - x_1) = 3 \times 0.4 \times 0.6 = 0.72$.

(d) Construct an algorithm to calculate and output survival rates for the first 10 months, assuming that $r = 3$ and an initial survival rate of 0.4. [5]

The following table shows a comparison between a model with a **constant survival rate** of 0.4 and a model with a **changing survival rate**, for the first nine months.

Population (Constant survival rate)	100	64	51	41	33	26	21	17	13	11
Population (Changing survival rate)	100	72	61	71	61	71	61	71	62	71

(e) With reference to the figures shown, suggest how these results could be used to compare the accuracy of the two models. [4]

(Option B continues on the following page)

(Option B continued)

5. Influenza is a contagious disease and a new form is spreading throughout a city. Some people are affected more than others and the illness is spreading more quickly in some parts of the city than in others. Members of the public can be given a vaccine that will prevent them from contracting influenza. Unfortunately, a limited amount of vaccine is available.

(a) Outline how the characteristics of the people most affected could be determined. [2]

Age, gender and current health may be factors that affect risk.

(b) Describe how a model of those most affected could be defined and applied to the population to estimate the number of people who are at risk. [4]

(c) Outline **one** limitation of the model. [2]

Each day the areas in the city where people have contracted the illness are recorded. These records can be used to simulate an estimate of the areas immediately at risk.

(d) Describe the process of testing and refining the simulation. [3]

(e) Discuss how this modelling and simulation could be used to limit the spread and impact of the illness. [4]

6. Bridges are modelled and these models are tested using sophisticated software before being presented for construction.

The software enables the architect to:
- define the shape of the bridge
- apply parameters such as width, length and material to the structure
- view the bridge from different perspectives
- test the strength and stability of the bridge under all conditions.

The architect starts by defining the basic shape of the required bridge. This includes the span of the bridge (from one end to the other), and the struts (pillars) that are needed to support the bridge. During this phase the architect has a wire frame image to work with. When the design is complete, the image is rendered to give a solid view of the bridge.

(a) Outline the way in which the wire frame image can be used by the architect to adjust the parameters and view the bridge from many different perspectives. [3]

(b) Describe how the wire frame image of the bridge is held in memory. [4]

(c) Suggest reasons for making changes on the wire frame model rather than the solid view model. [3]

(d) Suggest a strategy to test the model and ensure that the bridge will be safe once constructed. [4]

End of Option B

Option C — Web science

7. A large file is being downloaded from a website using TCP/IP protocols.

(a) Outline **one** difference between the internet and the World Wide Web (WWW). [2]

(b) Outline the function of the transmission control protocol (TCP) in the operation described above. [3]

The WWW is continually expanding and this has led to an upgrade in the internet protocol (IP). The IP that uses 32 bits is being replaced by one that uses 128 bits.

(c) Outline the reasons for replacing the 32 bit protocol. [3]

The new IP uses a different format for representing the address field in the packet.

(d) State the effect that this has on the domain name servers (DNS). [1]

(e) Evaluate the choice of compression software in the transfer of the file. [5]

8. ACAME is a company that offers a subscription service that permits the downloading of animated cartoons. When browsing their website the following uniform resource locator (URL) is visited:

http://minerva.hq.acame.net/Products/index.html

(a) Identify in the given URL

(i) the domain name of the server; [1]

(ii) the file path of the resource in the server. [1]

The web page contains the following line referring to a contact person.

mailto:sly.coyote@acame.net.

(b) Outline why an expression related to mail services provides a uniform resource identifier (URI) but not a URL. [2]

Access to part of the website is restricted and requires authentication.

(c) State **two** disadvantages of having the authentication based on the IP address of the client. [2]

ACAME has developed its website to be accessible on many different devices. CSS is used in the development of the website.

(d) With reference to this use of CSS

(i) describe **one** advantage for the user; [2]

(ii) describe **one** advantage for the web developer. [2]

The website is extremely popular. ACAME relies on a large network of servers to store and distribute their cartoons.

(e) Discuss the implications of having distributed systems. [5]

(Option C continues on the following page)

(Option C continued)

9. A user interacts with a web form in order to select the towns where there are schools with computer science classes. The web form has two windows, one for the **country**, and one for the **town** where a school is located. The web form is made interactive to the user so that when selecting a country, only the appropriate towns in that country are displayed.

(a) Describe how this interaction can be generated dynamically. [3]

By making the selection through the web form, the individual websites of the selected schools, including other resources and services, may be accessed.

(b) Outline the role of open standards in providing web-based services. [4]

Schools manage their own website and resources, and the school website must be easily retrieved.

(c) Explain **one** example of the use of a white hat technique to optimize the search process. [3]

(d) Discuss, with an example, how a Creative Commons license could be used in this situation. [6]

End of Option C

Option D — Object-oriented programming

In a particular country the Department of Transport analyses all of the train journeys of the different train companies in order to determine their reliability.

A team of programmers have created an OOP system for the Department of Transport to use.
The `TrainCompany` class is partially shown below.

```
public class TrainCompany
{
  private String companyName;
  private String companyCode;
  private int numberOfJourneys;
  private Journey[] journeyHistory = new Journey[100000];

  public TrainCompany(String x, String y)
  {
    this.companyName = x;
    this.companyCode = y;
    this.numberOfJourneys = 0;
  }
  public TrainCompany(){}

  // accessor and mutator methods

  Journey getJourney(int x)
  {
    return journeyHistory[x];
  }

  public void addJourney(Journey j)
  {
    journeyHistory[numberOfJourneys] = j;
    numberOfJourneys++;
  }

  public double averageDelay()
  {code missing}
  // returns the average delay for all of a company's journeys

  public String longestDelay(Codes[] c)
  {code missing}
  // returns the route name for the journey with the longest delay

  public String toString(Codes[] c)
  {code missing}
}
```

(Option D continues on the following page)

(Option D continued)

10. (a) By making reference to OOP features, outline why it is possible for the `TrainCompany` class to have two constructors. [3]

(b) Outline the consequence of having the accessor and mutator methods declared as **protected**. [2]

11. Every time a train journey is completed a `Journey` object is created. The `Journey` class is partially shown below.

```
public class Journey
{
    private … routeCode;
      // A unique identifier for a particular route
    private … delay;
      // Minutes late in arriving at the destination
    private … weatherRelated;
      // Equals true if the journey is affected by the weather,
      // otherwise false.
  // Constructor which initializes all 3 of the above data items
  // accessor and mutator methods.
}
```

(a) State the most appropriate data type for each of the three data items in the `Journey` class. [2]

(b) Construct the constructor method for the `Journey` class. [3]

The following code updates the journey information for each train company. This includes the creation of the data structure `allCompanies`, which is an array of `TrainCompany`.

```
TrainCompany[] allCompanies = new TrainCompany[3];

allCompanies[0] = new TrainCompany("Southern","T290");
allCompanies[1] = new TrainCompany("Northern","T400");
allCompanies[2] = new TrainCompany("Eastern","T155");

Journey s = new Journey("J100",3, false);
Journey t = new Journey("J103",8, true);
Journey u = new Journey("J104",10, true);

allCompanies[0].addJourney(s);
allCompanies[1].addJourney(t);
allCompanies[0].addJourney(u);
allCompanies[0].addJourney(new Journey("J101",6, false));

System.out.println(allCompanies[0].getCompanyCode());
System.out.println(allCompanies[0].getJourney(1).getDelay());
System.out.println(allCompanies[1].getNumberOfJourneys());
```

(c) State the output after the above code is executed. [3]

(Option D continues on the following page)

(Option D continued)

12. The Department of Transport requires data from each company regarding the average length of delays. Delays that are caused by the weather are **not** included.

The `averageDelay()` method in the `TrainCompany` class returns the average delay for all of the journeys. The method does **not** count delays caused by weather.

(a) State the value returned by the method call `allCompanies[0].averageDelay();`, assuming that the code in question 11 has been executed. [1]

(b) Construct the method `averageDelay()`. You can assume that each `TrainCompany` object has at least one journey. [6]

13. A further class, `Codes`, links each `routeCode` to the `routeName`, which contains the departure and destination stations, as shown below.

```
public class Codes
{
  private String routeName; // e.g. New Amsterdam – Diamond City
  private String routeCode;

  public Codes(String a, String b)
  {
    this.routeName = a;
    this.routeCode = b;
  }
  public String getRouteCode()
  {
    return routeCode;
  }

  public String getRouteName()
  {
    return routeName;
  }
}
```

(a) Construct the UML diagram for the `Codes` class. [3]

The array `allCodes[]` is an unordered array of `Codes` objects. It contains the details of every route for all of the train companies. The method `longestDelay()` in the `TrainCompany` class returns the route name for the journey with the longest delay not caused by the weather.

(b) Construct the method `longestDelay()`. You can assume that all route codes are present in `allCodes[]`. [7]

(Option D continues on the following page)

(Option D continued)

14. The Department of Transport wants to expand this program to include similar analysis for bus and airplane journeys.

(a) Describe how inheritance could be used to provide an organized set of classes for all of these forms of transport. [4]

(b) (i) Draw a diagram showing the dependencies between all of the classes described so far, including any introduced in part (a). You can assume that the `Journey` and `Codes` classes remain unchanged. [4]

(ii) Outline the reasons for keeping dependencies to a minimum. You should include an example using the classes described so far. [3]

The output from one call to the `toString()` method in the `TrainCompany` class is shown below.

```
Eastern : Average Delay = 2.5 minutes : Longest Delay = Newtown – Westlock Bay
```

(c) Construct the `toString()` method. You should make use of previously defined methods. [4]

End of Option D