Diploma Programme
Programme du diplôme
Programa del Diploma

Computer science
Standard level
Paper 2

5 May 2025

Zone A morning | **Zone B** morning | **Zone C** 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. Alpha Hospital is situated in a large city and has over 1000 staff. It stores its data in a relational database.

Some of the tables in this relational database contain data about the hospital staff, their roles, and the hospital departments.

Staff roles include doctor, nurse, pharmacist, radiologist, and support staff. Staff can only hold one role.

Departments include Accident and Emergency, Critical Care, Medical, General Surgery, Orthopaedics, and Ophthalmology. Staff can work in several departments.

The ROLE table, STAFF table, and DEPARTMENT table are shown in **Figure 1**.

Figure 1: Diagrammatic relationship for the ROLE table, STAFF table and DEPARTMENT table

ROLE
RoleID
PayGrade

STAFF
StaffID
RoleID
DepartmentID
FirstName
Surname
DateOfBirth

DEPARTMENT
DepartmentID
ManagerID
Building

(a) (i) State the primary key in the STAFF table. [1]

(ii) State a foreign key in the STAFF table. [1]

(b) Describe the relationships between the three tables in **Figure 1**. [2]

(c) Outline what a query is used for in a database. [2]

(d) Identify the steps to create a query to list the staff with the surname Waters who are on pay grade 17. The query must display **only** FirstName, Surname, and PayGrade. [4]

(e) Outline why an integer is an appropriate data type for the PayGrade field. [2]

(f) Explain **two** ways in which the database administrator can ensure the privacy of the hospital's staff data. [6]

(Option A continues on the following page)

(Option A continued)

2. Database design is a complex process that takes place in a range of phases. Different phases of database design use different schema.

(a) Describe the difference between a conceptual schema and a logical schema. [2]

(b) Explain the importance of a data definition language in implementing a data model. [2]

(c) Explain why data modelling is used during the development of a database. [4]

(d) Explain why both data validation and data verification are required to ensure the correctness of the data within a database. [3]

(e) Outline how data integrity is maintained during a database transaction. [2]

(f) Outline the role of relational integrity in maintaining data consistency within a database. [2]

(Option A continues on page 5)

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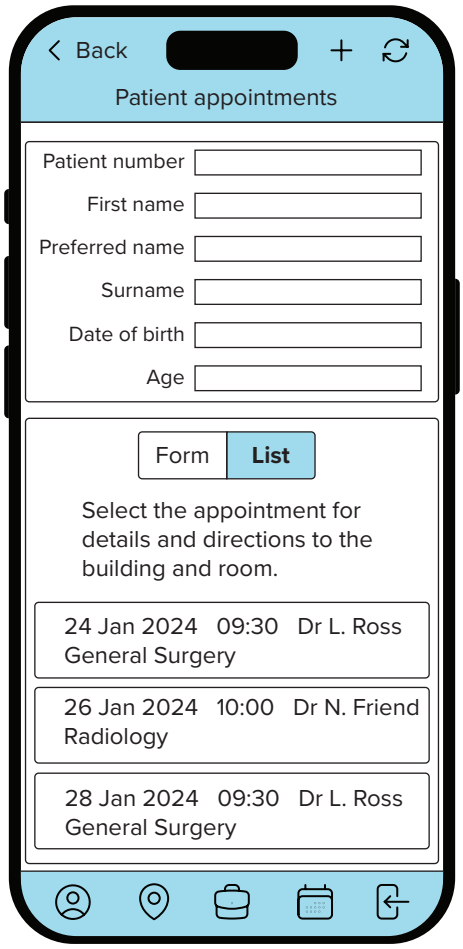
(Option A continued)

3. Alpha Hospital uses a database application to book appointments. Information can be shown in different formats.

Figure 2 shows an example of a patient's appointments displayed in the application.

Figure 2: A patient's appointments



The Age field is a derived field.

(a) (i) Outline **one** reason why a derived field would be used in a database. [2]

(ii) Describe how the derived field Age would be calculated. [2]

Patient information can be represented in the following format:

`PATIENT (PatientID, FirstName, Surname, PreferredName, DateOfBirth)`

(b) Outline the difference between first normal form (1NF) and second normal form (2NF). [2]

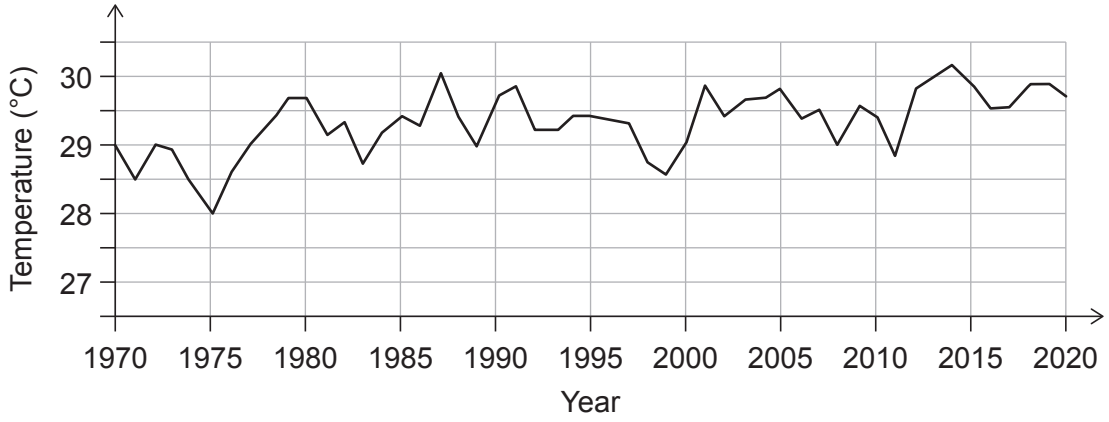
(c) Construct a database in third normal form (3NF) for all of the data shown in **Figure 2**. You should use database notation as shown in the PATIENT table. [6]

End of Option A

Option B — Modelling and simulation

4. Global warming can be measured over time using mean temperatures. **Figure 3** shows the mean daily maximum temperatures from 1970 to 2020 for Nauru, an island in the Pacific Ocean.

Figure 3: Mean daily maximum temperatures for Nauru, 1970–2020



(a) State **two** variables that are necessary for the mean daily maximum temperature to be calculated. [1]

(b) Identify the steps that would be used to create the diagram exactly as shown in **Figure 3** using the data in a spreadsheet. [3]

(c) Identify **two** reasons why the mean daily maximum temperature data is presented in graphical form. [2]

An automated system is used to collect the temperature data for Nauru once an hour for one year.

(d) Outline **one** reason why the temperature data is collected once an hour rather than at shorter intervals, such as once a minute. [2]

(e) Describe the steps that should be used to store the data collected for one day (24 hours) in suitable parallel one-dimensional (1D) arrays.

The time the data was collected must be easy to identify. **Do not** write a pseudocode algorithm. [5]

(Option B continues on the following page)

(Option B, question 4 continued)

The temperature data is downloaded every day and collated into a master file.

The data from the master file is loaded into a suitable array for that 24-hour period.
The following statistics are calculated:

- Maximum temperature
- Minimum temperature
- Mean temperature

As Nauru is very close to the equator, the length of the day changes very little throughout the year. For the purposes of part (f), the lengths of its day and night are:

- Day: 07:00 to 18:59 inclusive (12 hours)
- Night: 19:00 to 06:59 inclusive (12 hours)

(f) Construct a pseudocode algorithm to calculate the:

- maximum temperature
- minimum temperature
- mean temperature
- mean night-time temperature.

Assume the arrays for the time of day of the reading and hourly temperature readings have already been set up and populated as parallel 1D arrays. [8]

(Option B continues on the following page)

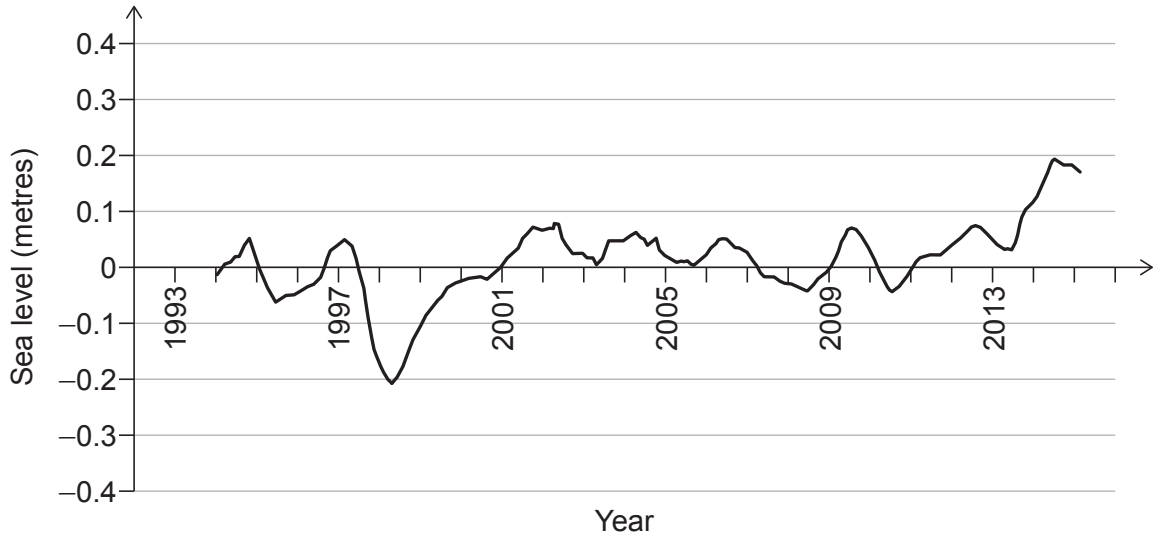
(Option B continued)

5. The global increase in mean temperatures is causing concern, and governments are using computer models to determine potential future changes.

Many islands in the Pacific Ocean are close to or below sea level and have observed an increased incidence of coastal flooding. This suggests there is a relationship between the increase in mean temperatures and the increase in mean sea levels.

Figure 4 shows the mean sea level of Nauru from 1994 to 2015.

Figure 4: Mean sea level of Nauru, 1994–2015



If the mean sea level rises, the probability of coastal flooding will also increase. This will put many of the inhabitants of Nauru at risk.

It has been proposed that a simulation be developed to show the effects of rising temperatures on the extent and frequency of coastal flooding.

(a) Distinguish between a model and a simulation. [2]

(b) Describe how to identify the rules required to create a simulation from the mean temperature and mean sea level data. [3]

(c) Evaluate how test cases could be used to effectively validate the accuracy of this proposed simulation. [6]

(d) Discuss the advantages **and** disadvantages of using a simulation for decision making in the coastal areas of islands in the Pacific Ocean. [5]

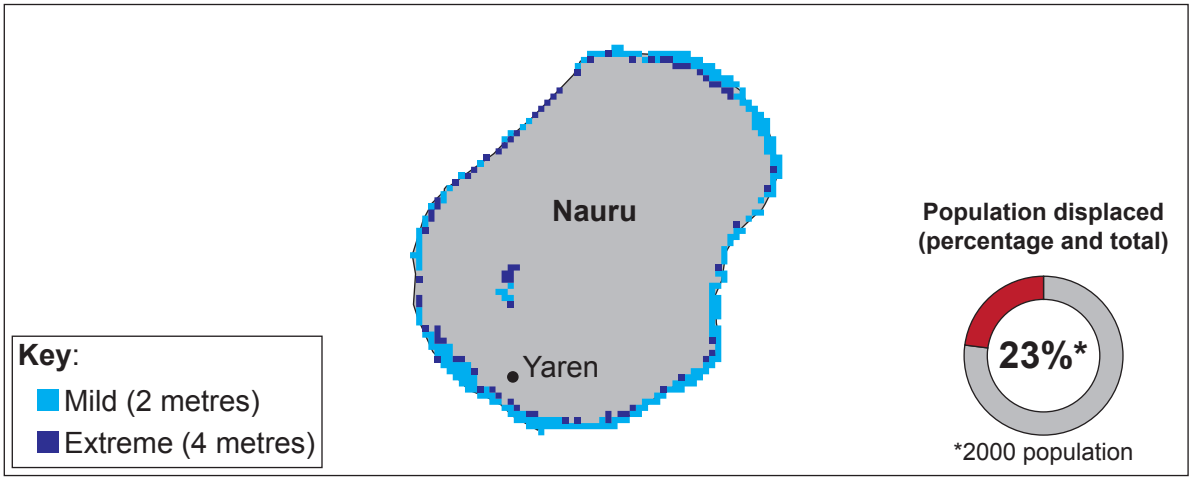
(Option B continues on the following page)

(Option B continued)

6. Organizations such as Earth.Org have raised concerns about the rate of sea level increase for Nauru. They stated, “Sea level rise is 2 to 3 times faster around Nauru than the global average, putting its freshwater supplies and crops at risk of saltwater contamination. Already reliant on economic aid, Nauru’s basic resource needs may have to be acquired externally for life to be sustained on the island.”

The 2D visualisation in **Figure 5** shows the projected impact of mild and extreme sea level increases on Nauru by 2100.

Figure 5: Projected impact of mild and extreme sea level increases on Nauru by 2100



[Source: https://earth.org/data_visualization/sea-level-rise-by-2100-nauru/.]

(a) Define the term *visualization*. [1]

There are proposals to develop a 3D visualization of the impact of rising sea levels on Nauru.

(b) Outline the relationship between images stored in memory and 3D visualizations. [2]

(c) Discuss the time and memory considerations of 3D animation in the proposed 3D visualization for Nauru. [5]

End of Option B

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Option C — Web science

7. Alexia and Jay are discussing their use of online resources to prepare for their IB examinations. They often visit websites such as BBC Bitesize.

Alexia refers to accessing the websites as “surfing the internet” and Jay refers to the resources as being “on the web”.

(a) Distinguish between the internet and the World Wide Web. [2]

The uniform resource locator (URL) for the BBC Bitesize website is as follows:

https://www.bbc.co.uk/bytesize/index.htm

(b) Identify **two** characteristics of a URL. [2]

Jay wants to transfer a file to Alexia and suggests they use file transfer protocol (FTP).

(c) Identify **two** characteristics of file transfer protocol. [2]

(d) Explain how a web browser functions. [3]

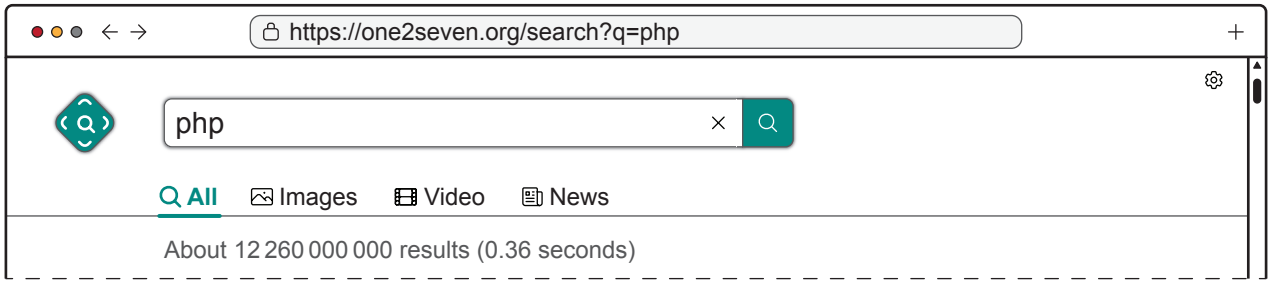
(Option C continues on the following page)

(Option C continued)

8. Alexia and Jay are researching the web development language PHP.

They type the phrase “PHP” directly into a web browser (see **Figure 6**).

Figure 6: “PHP” typed into a web browser and redirected to a search engine



The web browser redirects them to a popular search engine, which executes a search.

(a) Define the term *search engine*. [1]

The operation of a search engine can be divided into three steps (see **Figure 7**).

Figure 7: The three steps in the operation of a search engine

(b) Describe how a web crawler functions. [2]

(c) Outline why keywords are important for web indexing. [2]

(d) Discuss whether an organization should use black hat search engine optimization (SEO) techniques to improve the ranking of its website. [6]

Search engines return a very large number of results, but many of the web pages are not useful. The search needs to be refined.

Alexia and Jay’s teacher recommended that they use an online database that accesses the deep web.

(e) Distinguish between the surface web and the deep web. [2]

(Option C continues on the following page)

(Option C, question 8 continued)

One of the online databases provides Alexia and Jay with the following code:

```
<?php
    if(isset($_FILES['CV'])){
        $errors= array();
        $file_name = $_FILES['CV']['name'];
        $file_size =$_FILES['CV']['size'];
        $file_tmp =$_FILES['CV']['tmp_name'];
        $file_type=$_FILES['CV']['type'];

        $file_ext=strtolower(end(explode('.',$_FILES['CV']['name'])));

        $extensions= array("pdf","doc","docx");

        if(in_array($file_ext,$extensions)=== false){
            $errors[]="This file extension not allowed";
        }

        if($file_size > 2097152){
            $errors[]="File size must be under 2 Mb";
        }

        if(empty($errors)==true){
            move_uploaded_file($file_tmp,"CV/".$file_name);
            echo "Success";
        }else{
            print_r($errors);
        }
    }
?>
<html>
<body>
    <h1>Curriculum Vitae</h1>
    <form action="" method="POST" enctype="multipart/form-data">
        <input type="file" name="CV" />
        <input type="submit"/>
    </form>
</body>
</html>
```

(f) Identify **four** steps that take place during the processing of this PHP code. [4]

The PHP code is processed on the server.

(g) Explain why an organization would choose to use server-side processing rather than client-side processing when delivering content to the client. [3]

(Option C continues on page 15)

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(Option C continued)

9. A social media file-sharing website allows users to upload their original video content.

The site provides an upload module that uses lossless compression.

(a) Outline how lossless compression maintains the quality of a media file. [2]

When a file is decompressed, the content is rendered to fit a standard set of sizes, aspect ratios, and frame rates. Standard video formats, such as MP4, are used for the output of media.

The file format MP4 or MPEG-4 is an open standard for media files.

(b) Identify **two** characteristics of an open standard. [2]

Social media sites use a distributed system where the data is stored in many countries.

In the European Union, Argentina, and the Philippines the right to be forgotten has been established as law. The right to be forgotten means a person has the right to have private information removed from databases and applications so it cannot be found in an internet search.

(c) Discuss the impact of the decentralized web on an individual's right to privacy. [6]

Xero, a small software company, was established in 2006 in Wellington, New Zealand. It produced an easy-to-use accountancy service for small to medium enterprises. This product was based on the software-as-a-service (SaaS) model and is sold in a subscription format all over the world. Customer data is securely stored online as part of the subscription cost.

(d) Explain how developments in the web have enabled small companies such as Xero to have a global reach. [6]

End of Option C

Option D — Object-oriented programming

10. An art shop sells the work of several artists. Each artist has many artworks for sale. A system is designed to manage artworks, sales and customers.

The following shows part of the code for the two classes, `Artist` and `Artwork`:

```
public class Artist {

    private String artistName;      // name of the artist
    private String artistLocation;  // current location of the artist
    private int noOfArtworks;       // number of works of art the artist has
                                    // stored in the array theArtworks
    private Artwork [] theArtworks; // details of the works of art produced
                                    // by the artist

    public Artist(String artistName, String artistLocation){
        this.artistName = artistName;
        this.artistLocation = artistLocation;
        noOfArtworks = 0;
        theArtworks = new Artwork [100]; // an artist has a maximum of 100
                                         // artworks
    }

    public String getName() {
        return artistName;
    }

    public String getLocation() {
        return artistLocation;
    }

    public Artwork getArtwork(int x) {
        return theArtworks[x];
    }

    public void addArtwork(Artwork x) {
        theArtworks[noOfArtworks] = x;
        noOfArtworks = noOfArtworks + 1;
    }

    public double commissionToPay() {
        // code missing
    }

    public Artwork[] sortArt() {
        // code missing
    }

} // end of class Artist
```

(Option D continues on the following page)

(Option D, question 10 continued)

```
public class Artwork {

    private String artworkTitle; // name of the artwork
    private int artworkPrice;    // price of artwork
    private boolean isSold;      // if the artwork has been sold or not

    public Artwork(String artworkTitle, int artworkPrice) {
        this.artworkTitle = artworkTitle;
        this.artworkPrice = artworkPrice;
        isSold = false; // default value is not sold
    }

    public String getArtworkTitle(){
        return artworkTitle;
    }

    public void isSold(){
        isSold = true;
    }
} // end of class Artwork
```

(a) State the relationship between the `Artist` class and `Artwork` class. [1]

(b) Outline what is meant by instantiation of an object. [2]

(c) Construct the code required to instantiate the artist “Thomas Lucas” from “Ireland”. [3]

(d) With reference to the `Artist` and `Artwork` classes, outline the use of the modifier `private`. [2]

(e) Outline **two** advantages of modularity in program development. [4]

(f) Construct a UML diagram to represent the `Artist` class. [3]

(Option D continues on the following page)

(Option D continued)

11. The owner of the art shop would like the artworks separated into three different categories: paintings, sculptures, and performances.

Three classes, `Painting`, `Sculpture`, and `Performance`, are created for the three different categories of artwork.

The variable `typeOfPaint` belongs to `Painting`. It holds the name of the type of paint used.

The variable `weight` belongs to `Sculpture`. It holds the weight of a sculpture.

The variable `needForSound` belongs to `Performance`. It states whether sound is needed for the performance.

The other variables are common to all three classes.

(a) State a suitable data type for:

(i) the variable `typeOfPaint`; [1]

(ii) the variable `weight`; [1]

(iii) the variable `needForSound`. [1]

(b) (i) Outline **two** advantages of using inheritance. [4]

(ii) Explain how inheritance could be used to develop the three classes described (`Painting`, `Sculpture`, and `Performance`). [3]

An array of type `Artist` has been declared in the main class, and objects are added using the following code:

```
theArtists[0] = new Artist("Nishan Nathan", "Italy");
theArtists[1] = new Artist("Saskia Anna", "Egypt");
theArtists[2] = new Artist("Kate Matherson", "USA");
```

The variable `isSold` in the `Artwork` object needs to be set to `true` when an artwork has been sold.

(c) Construct a method, `Sold(String artistName, String artworkTitle)`, that will loop through the array `theArtists` array and set the `isSold` variable to `true`.

You can assume the artwork exists in `theArtworks` array. [6]

(Option D continues on the following page)

(Option D continued)

12. The system, which is designed to manage artworks, sales and customers, should have methods to find artworks that match a specific request made by a customer.

For example, a customer may want to find all artworks by Sebastián Müller.

(a) State the initial value of `noOfArtworks` for an artist. [1]

(b) Construct the method `sortArt()` in the `Artist` class that will find the five most expensive artworks for a given artist.

You must make use of the selection sort algorithm. [5]

Artists must pay a 15 % commission to the shop for each of their artworks sold there.

The method `commissionToPay` calculates the commission to be paid by an artist on all sold artworks.

(c) Construct the method `commissionToPay` that will calculate and return the amount of commission to be paid by the artist to the shop. [6]

(d) Outline why Unicode enables internationalization. [2]

End of Option D

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References:

Figure 4 ClimateDataInfo, n.d. *Sea Levels - Pacific Islands.* [online] Available at: http://www.climatedata.info/impacts/sea-levels/pacific-islands/ [Accessed 13 August 2024]. Source adapted.

Question 6 [Figure 5] Mulhern, O., 2020. *Sea Level Rise Projection Map – Nauru*. [online] Available at: https://earth.org/data_visualization/sea-level-rise-by-2100-nauru/ [Accessed 13 August 2024]. Source adapted.

[Quotation] Mulhern, O., 2020. *Sea Level Rise Projection Map – Nauru*. [online] Available at: https://earth.org/data_visualization/sea-level-rise-by-2100-nauru/ [Accessed 13 August 2024].

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