© International Baccalaureate Organization 2023

All rights reserved. No part of this product may be reproduced in any form or by any electronic or mechanical means, including information storage and retrieval systems, without the prior written permission from the IB. Additionally, the license tied with this product prohibits use of any selected files or extracts from this product. Use by third parties, including but not limited to publishers, private teachers, tutoring or study services, preparatory schools, vendors operating curriculum mapping services or teacher resource digital platforms and app developers, whether fee-covered or not, is prohibited and is a criminal offense.

More information on how to request written permission in the form of a license can be obtained from https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/.

© Organisation du Baccalauréat International 2023

Tous droits réservés. Aucune partie de ce produit ne peut être reproduite sous quelque forme ni par quelque moyen que ce soit, électronique ou mécanique, y compris des systèmes de stockage et de récupération d'informations, sans l'autorisation écrite préalable de l'IB. De plus, la licence associée à ce produit interdit toute utilisation de tout fichier ou extrait sélectionné dans ce produit. L'utilisation par des tiers, y compris, sans toutefois s'y limiter, des éditeurs, des professeurs particuliers, des services de tutorat ou d'aide aux études, des établissements de préparation à l'enseignement supérieur, des fournisseurs de services de planification des programmes d'études, des gestionnaires de plateformes pédagogiques en ligne, et des développeurs d'applications, moyennant paiement ou non, est interdite et constitue une infraction pénale.

Pour plus d'informations sur la procédure à suivre pour obtenir une autorisation écrite sous la forme d'une licence, rendez-vous à l'adresse https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/.

© Organización del Bachillerato Internacional, 2023

Todos los derechos reservados. No se podrá reproducir ninguna parte de este producto de ninguna forma ni por ningún medio electrónico o mecánico, incluidos los sistemas de almacenamiento y recuperación de información, sin la previa autorización por escrito del IB. Además, la licencia vinculada a este producto prohíbe el uso de todo archivo o fragmento seleccionado de este producto. El uso por parte de terceros —lo que incluye, a título enunciativo, editoriales, profesores particulares, servicios de apoyo académico o ayuda para el estudio, colegios preparatorios, desarrolladores de aplicaciones y entidades que presten servicios de planificación curricular u ofrezcan recursos para docentes mediante plataformas digitales—, ya sea incluido en tasas o no, está prohibido y constituye un delito.

En este enlace encontrará más información sobre cómo solicitar una autorización por escrito en forma de licencia: https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/.

Diploma Programme
Programme du diplôme
Programa del Diploma

Computer science
Higher level
Paper 1

5 May 2023

Zone A morning | **Zone B** afternoon | **Zone C** afternoon

2 hours 10 minutes

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer all questions.
- The maximum mark for this examination paper is **[100 marks]**.

2223 – 9240

7 pages

© International Baccalaureate Organization 2023

International Baccalaureate®
Baccalauréat International
Bachillerato Internacional

Section A

Answer **all** questions.

1. Outline the function of a web browser. [2]

2. Identify **two** applications of queues in computing. [2]

3. Outline **one** reason for using Unicode to represent data in a computer system. [2]

4. Sensors that take readings of the levels of different pollutants have been installed at a number of sites along a river. Each reading is sent to a central computer, where it is processed and analysed.

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

(b) Describe how polling could be used in this situation. [3]

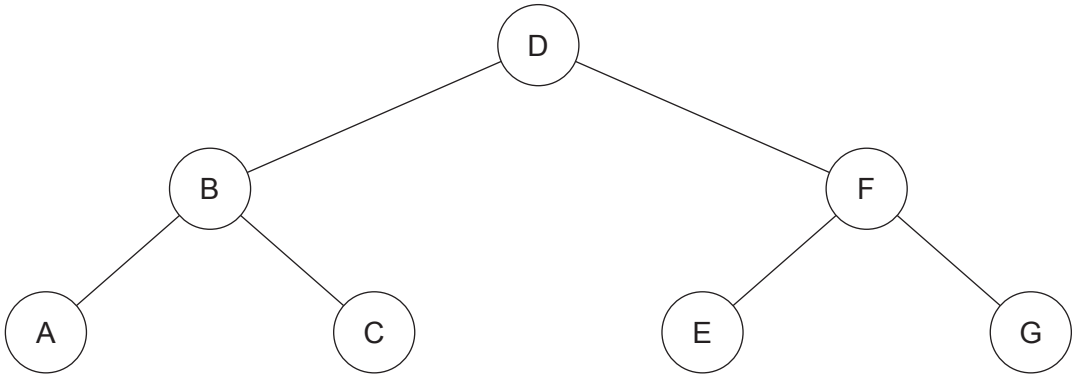
5. Construct a truth table for the logic expression [4]

A NAND (B NOR C)

6. Outline what is meant by a collection. [2]

7. Distinguish between random access memory (RAM) and read-only memory (ROM). [2]

8. Consider the following binary tree, in which each node stores a value greater than all the values in the node's left subtree and less than those in its right subtree.



(a) Identify the leaf nodes in this binary tree. [1]

(b) State the result of the postorder traversal. [1]

(c) Sketch the resulting binary tree after the deletion of the root node. [3]

9. Outline **one** advantage of the use of virtual memory. [2]

Section B

Answer **all** questions.

10. An organization needs to improve its current computer systems. The systems are legacy systems with a large number of end users.

(a) Identify **two** issues concerning the roles of end users that must be considered in relation to the new system. [2]

(b) Outline the meaning of the term “legacy system”. [2]

(c) Identify **one** method of gathering requirements from end users. [1]

The organization needs to use existing data in the new system.

(d) Explain **one** problem that may occur during data migration. [3]

A decision needs to be made on whether to use parallel running or a direct changeover method of implementation.

(e) Explain **one** advantage of using parallel running instead of a direct changeover. [3]

(f) End users will require training in the use of the new system.

(i) Identify **one** method of training for end users. [1]

(ii) Evaluate the advantages and disadvantages for the end user of the method of training identified in (f)(i). [3]

11. Many organizations use a virtual private network (VPN) to enable employees working remotely to access files that are held on the organization’s server.

(a) State **two** technologies that are required to provide a virtual private network (VPN). [2]

(b) Identify **two** factors that may affect the speed of data transmission. [2]

(c) Explain why data compression would be used when data is transmitted. [3]

A large amount of sensitive data is stored online and needs to be protected.

(d) Outline how encryption is used to protect data. [2]

(e) Describe the role of a firewall. [2]

Employees are increasingly working from home.

(f) Discuss the social impacts of this changed work pattern on employees. [4]

12. Smart control systems can manage the temperature within a house.

(a) Outline the steps involving the sensor, processor and output transducer to manage the temperature in the house. [5]

(b) Describe the role of feedback in this control system. [2]

(c) The smart control system is managed by an operating system.

(i) Describe **one** function of an operating system. [2]

(ii) Outline **one** reason why a dedicated operating system would be used. [2]

(d) Compare and contrast a centralized control system with a distributed control system for managing the temperature of a house. [4]

13. Consider the following recursive method:

```
rec(A)
    if A >= 2
        then
            return rec(A-2) + rec(A-1)
        else
            return 1
    end if
end rec
```

(a) Determine the value of `rec(5)` (*show all your working*). [4]

(b) Outline **two** disadvantages of recursive methods. [4]

A stack is a data structure that is used in the implementation of a recursive method.

(c) Outline the purpose of the stack access method `isEmpty()`. [2]

The stack `TOWNS` holds several town names, and the name "Cardiff" is on the top of the `TOWNS` stack (see **Figure 1a**).

An algorithm is needed that will reverse the contents of the `TOWNS` stack. The name "Geneva" should be on top of the `TOWNS` stack after reversing its contents (see **Figure 1b**).

Figure 1: Example data held on the `TOWNS` stack before and after execution of the requested algorithm

a. The content in the `TOWNS` stack **before** it is reversed

Cardiff
Washington DC
The Hague
Singapore
Geneva

b. The content in the `TOWNS` stack **after** it is reversed

Geneva
Singapore
The Hague
Washington DC
Cardiff

(d) Construct an algorithm that will reverse the `TOWNS` stack **using an empty queue**. You may assume that the `TOWNS` stack is inputted and a new empty queue named `TEMP` is initialized.

You must use stack access methods **and** queue access methods in your response. [5]

14. A program is developed to simulate the roll of dice in a game.

Three dice are thrown, with faces that have numbers from 1 to 6.

The dice are thrown seven times, and the data are stored in a two-dimensional array called `DICEDIAL` (see **Figure 2**).

Figure 2: The example data stored in the `DICEDIAL` array

	[0]	[1]	[2]
[0]	4	2	2
[1]	4	4	4
[2]	5	2	3
[3]	6	5	5
[4]	5	5	6
[5]	1	1	4
[6]	3	2	1

(a) Construct an algorithm in pseudocode to calculate the product of all values stored in the `DICEDIAL` array. [3]

The sub-program `DuplicateNum(DICEDIAL,R)` checks whether there are repeated numbers in row `R`. If the numbers are not repeated, it returns 0, otherwise it returns the repeated number.

The `DuplicateNum()` sub-program will produce the following from the values used in **Figure 2**:

`DuplicateNum(DICEDIAL,0)` returns 2

`DuplicateNum (DICEDIAL,1)` returns 4

`DuplicateNum(DICEDIAL,2)` returns 0

(b) Construct an algorithm in pseudocode for the sub-program `DuplicateNum(DICEDIAL,R)`. [4]

The sub-program `lowestRT(DICEDIAL)` accepts the `DICEDIAL` array and outputs the lowest row total and the indexes of all the rows with that total.

From the example data given in **Figure 2**, `lowestRT(DICEDIAL)` would output that the lowest row total is **6**, and it occurs in the rows with indexes **5** and **6**.

(c) Construct an algorithm in pseudocode for the sub-program `lowestRT(DICEDIAL)`. [8]