Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2023

Computer science

Standard level

Paper 1

14 pages

International Baccalaureate®
Baccalauréat International
Bachillerato Internacional

© 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/.

Subject details: Computer science SL paper 1 markscheme

Mark allocation

Section A: Candidates are required to answer **all** questions. Total 25 marks.
Section B: Candidates are required to answer **all** questions. Total 45 marks.
Maximum total = 70 marks.

General

A markscheme often has more specific points worthy of a mark than the total allows. This is intentional. Do not award more than the maximum marks allowed for that part of a question.

When deciding upon alternative answers by candidates to those given in the markscheme, consider the following points:

- Each statement worth one point has a separate line and the end is signified by means of a semi-colon (;).
- An alternative answer or wording is indicated in the markscheme by a "/"; either wording can be accepted.
- Words in (…) in the markscheme are not necessary to gain the mark.
- If the candidate's answer has the same meaning or can be clearly interpreted as being the same as that in the markscheme then award the mark.
- Mark positively. Give candidates credit for what they have achieved and for what they have got correct, rather than penalizing them for what they have not achieved or what they have got wrong.
- Remember that many candidates are writing in a second language; be forgiving of minor linguistic slips. In this subject effective communication is more important than grammatical accuracy.
- Occasionally, a part of a question may require a calculation whose answer is required for subsequent parts. If an error is made in the first part then it should be penalized. However, if the incorrect answer is used correctly in subsequent parts then **follow through** marks should be awarded. Indicate this with "**FT**".

General guidance

Issue	Guidance
Answering more than the quantity of responses prescribed in the questions	• In the case of an "identify" question, read all answers and mark positively up to the maximum marks. Disregard incorrect answers. • In the case of a "describe" question, which asks for a certain number of facts *eg* "describe two kinds", mark the first two correct answers. This could include two descriptions, one description and one identification, or two identifications. • In the case of an "explain" question, which asks for a specified number of explanations *eg* "explain two reasons …", mark the first two correct answers. This could include two full explanations, one explanation, one partial explanation *etc*.

Section A

1. *Award **[2 max]***
web browser allows users access to information/resources on the WWW;
(when a user asks for a particular website) the web browser fetches the required content from a web server/ acts as an interface between a client and server;
prepares the retrieved information to be displayed/ interprets the content to be rendered in a format that can be understood/ displays the resulting web page on the user's device;
allows user to navigate around website/ open more than one web page/ print/ save page/ etc. ;

2. *Award **[1 max]***
holds the address of the current instruction/data that is to be fetched from / transferred to memory;

3. *Award **[2 max]***
Because Unicode is (an established) standard for data representation/ a single encoding scheme for all languages and characters;
So, data can be used/transported through many different systems/ platforms/ devices;

Because of the difference between ASCII and Unicode in the number of bits used to encode (ASCII (8-bits) and Unicode (16/32 bits);
It can represent over a million characters/ ASCII cannot be used to encode the many types of characters found around the world;

Because Unicode can be defined with different character encoding like UTF-8, UTF-16, UTF-32, etc.;
And is used to represent many (over a million) characters from many (more than 150) modern and historic scripts (along with emoji);

4. (a) *Award **[1 max]***

Random Access Memory is volatile / requires power to maintain the stored information/ data is retained in RAM as long as the computer is on, but it is lost when the computer is turned off;
Data/instructions that are currently being used are stored in RAM;
RAM can be modified, erased, or read/ data stored in RAM can be altered;
RAM is small in capacity compared to secondary storage media;
It is fast (faster to read from and write to than other kinds of storage, such as a hard disk drive (HDD)/ solid-state drive (SSD));

(b) *Award **[3 max]***

Cache memory is (an extremely) fast memory type;
that acts as a buffer between RAM and the CPU;
it holds frequently requested data and instructions;
so that they are immediately available to the CPU when needed;

Cache memory is used as an intermediate form of storage between very high-speed CPU registers and the slower RAM;
located inside the CPU and can be directly accessed by the processor;
It is used to store instructions and data that are repeatedly required during the execution of programs; thus, improving the performance and speed of the whole system/ thus avoiding the need to access the dynamic RAM to retrieve the same data repeatedly/ is used to reduce the average time to access data from the main memory;

5. *Award **[4 max]***

*Award **[1]** for every 2 correct rows in the truth table.*

A	B	C	A NAND (B NOR C)
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

6. *Award **[2 max]***
*Award **[1]** for structure and **[1]** for methods/properties.*

A collection is a grouping of a variable number of data items into a single unit;
that need to be operated upon together;

A collection is a term used to describe a data structure designed to contain multiple elements of any type;
and methods which make this data useful; *Accept example methods, such as methods given in IB pseudocode: hasNext(), getNext(), resetNext(), etc. ;*

A collection is a class used to represent a set of similar data type items as a single unit (such as an array list, linked list, stack, queue);
and methods used for efficient data manipulation/ and the set of methods that are common to all data items;

7. *Award **[2 max]***
Physical layer;
Data Link layer (DLL);
Network layer;
Transport layer;
Session layer;
Presentation layer;
Application layer;

8. (a) *Award [4 **max**]*
Award [1] for a trace table with at least 4 columns (K, A, B, Output)
Award [1] for correct column K
Award [1] for correct column A
Award [1] for correct column B
Award [1] for correct column Output

Example:

***Note**: The trace table may be differently presented.*

K	A	B	K>=0	DATA[K]	DATA[K] mod 2 <1	Output
5	1	0	True	2	True	
4	2		True	6	True	
3	12		True	19	False	
2		1	True	5	False	
1		2	True	21	False	
0		3	True	7	False	
-1		4	False			
						12
						4

(b) *Award [2 **max**]*
It counts the number of odd numbers held in the DATA array;
It calculates the product of the even numbers held in the DATA array;

9. *Award **[2 max]***
one of the key concepts of OOP languages;
to decompose complex problems;
Hide / remove unnecessary details;
look for recurring patterns;

Example 1 (OOP)
Abstraction is a process in which a programmer hides / removes all but the relevant data about an object;
in order to reduce complexity / increase efficiency;

Example 2 (OOP)
Abstraction in OOP is a programming methodology in which details of the programming codes are hidden away from the user;
and only the essential things are displayed to the user;

Example 3 (OOP)
Abstraction is one of the key concepts of OOP languages;
its main goal is to handle complexity (by hiding/removing unnecessary details);

Example 4
Abstraction is the process of ignoring the characteristics of patterns that we don't need;
in order to concentrate on those that we do need;

Example 5
Abstraction means decomposing complex problems;
And then looking for patterns among and within the smaller problems (that make up the complex problem);

Section B

10. (a) Award ***[2 max]***

*Award **[1]** for identifying an issue (benefit or problem) caused by the introduction of a new computer system which transforms how end users perform and interact, **x2**.*

Examples *(the list is not exhaustive):*
Need for training;
(lack of knowledge of the end-users about the new system/ lack of ability to use the new system/ resistance to training?);

Resistance to changes;
(turnover-some end users leave the organisation, end user not giving feedback or requirements for the new system);

End-user satisfaction;
(end-users excited about changes? increased efficiency/ productivity/ increased employee morale);

Change in roles/ role specification;
(agreements/ disagreements on job duties/ fear of redundancy);

Poor processes management;
(employees may not understand what is expected of them/ employees could feel that new practices are in conflict with previous/ existing practices);

(b) *Award **[2 max]***
Legacy system is an outdated computer system/(application) software that is still in use/ still meets the needs it was originally designed for/ is essential for the organization;
it cannot be updated /does not receive support and maintenance/ doesn't allow for growth/ is incompatible with current (new) more advanced solutions;

(c) *Award **[1 max]***
Observation ;
Survey/Questionnaire ;
Interview;
Brainstorming (get as many ideas as possible from a representative group of end users);

(d) *Award **[3 max]***
Example 1
Data loss/data available in legacy system but after migration process it is not available in the new system;
because data is accidentally deleted/ something causes data to become corrupted/ viruses/ physical damage/incomplete transfer;
cost involved in rectifying data loss leads to financial risk for the organization / sets back productivity / reputation risk (can cause the organization to lose customers);

Example 2
Data Corruption/ Data integrity;
format and content of data in legacy system and new system is different / incompatible data/ anomalies or redundant or duplicated data or presence of non-meaningful data;
this affects the efficiency/ it can totally beat purpose of migration;

Note: Students may write an example for this, such as: the legacy system may have had gender details of the employees, but the new system may not have/require them).

(e) *Award **[3 max]***

Example 1
Parallel running is less risky than direct changeover;
if the new system fails, operation can continue under the old system;
whilst in direct changeover if the new system fails the data is lost/ operation cannot continue;

Example 2
Parallel running allows organization to test the new system (all features of the new system can be fully trialled);
and the organization switches over to the new one if (when) it is found to be more efficient than the old one;
Whilst in direct changeover the new system is started without ensuring that the new system is working correctly/efficiently before the old system is terminated;

Example 3
Parallel running ensures new system runs without errors;
if errors are found, refer to old system to resolve and make modifications to new system;
Whilst in direct changeover the old system is terminated (and the new system is started without ensuring that it is working correctly);

Example 4
Parallel running allows staff to be trained in the new system gradually;
helps them gain confidence in new system;
as the changeover does not happen immediately;

***Note**: Reward other suitable responses.*

(f) (i) *Award **[1 max]***
self -instruction/self-learning;
formal classes;
remote/online training;

***Note:** Reward other suitable methods.*

(ii) *Award **[3 max]***
*Award up to **[2]** for any advantage to end-user (trainee) evaluated, and **up to** [2] for any disadvantage evaluated.*
Note: The response should match the method of training identified in (i).

Award marks for the advantages and disadvantages involving convenience, cost, time, effectiveness, comprehensiveness, learning needs, etc.

Example 1 *(remote /online training)*
advantage of online training is that it allows end-users to attend classes from any location of their choice;
with reduced financial costs (because online learning eliminates the cost of transportation/ meals/ the study materials are cheaper (available online));
but there are also disadvantages such as: struggle with focusing on the screen for long periods of time/ technology issues (requirements of internet enabled devices / smart devices / live internet connection) /sense of isolation/ time zone differences between the trainer and the trainees;

Example 2 (*formal classes*)
Direct interaction between the trainer and trainees (end-users); no technology issues/no sense of isolation;
Verified study materials and trainers allows immediate answer to end-users/ gives end-user (trainees) the benefit of receiving immediate feedback;
but it involves high costs (the expenses associated with end-user training);
it is time intensive/requires time away from the work;

Example 3 (*self-instruction*)

Self-learning is neither location constrained nor time-bound (end users can choose their own pace/materials/methods);
less stressed out about failing in front of another person/no social interaction;
lack of input from trainers can lead to slower progress than f2f training;

11. (a) *Award **[2 max]***

(VPN) tunnelling (server);
(VPN aware) router (and firewall);
Encryption (protocol) (A*ccept examples IPSec/ SSL / TSL*);
VPN client software (installed on the employee's computer);

(b) *Award **[2 max]***
physical distance/ the number of network devices which have to be crossed;
the performance of each of the devices (sender and receiver), for example weak processor;
quality/characteristics of network equipment (such as the router or transmission media/ cable/fibre/wireless);
number of network users (and their demand at any particular time);

Accept other reasonable answers, such as the type of encryption used or the encryption strength/ server bandwidth/ size of the user data/ type of protocol used, etc.;

(c) *Award **[3 max]***
(Because) compression reduces the size of a file/ size of data/ the number of packets to be transmitted;
Which reduces transmission time/ consumes less bandwidth;
And can result in significant cost savings;

(d) *Award **[2 max]***
Encryption scrambles readable text;
So, it can only be read/understood by the person who has the decryption key;

Data encryption translates plain text into ciphertext;
That can be viewed/read in its original form only if it is decrypted with the correct key;

(e) *Award **[2 max]***
A firewall monitors incoming and outgoing network traffic;
and decides whether to allow or block specific traffic (based on a defined set of security rules)/ restricts access to parts of a network / prevents unauthorised access of confidential data);

***Note**: Accept software and hardware firewalls.*

A (software) firewall (is a program installed on each computer that) monitors incoming and outgoing traffic/ controls the behaviour of applications;
and filter/block traffic coming from unsecured or suspicious apps/ blacklisted apps;

A (hardware) firewall (is a piece of equipment installed between the network and gateway that) regulates traffic through ports;
and prohibits suspicious data packets from passing through;

(f) *Award **[4 max]***
*Award **[2 max]** for positive aspects, 1 mark for stating any of the positive aspects (of working from home) and 1 mark for discussion.*
*Award **[2 max]** for negative aspects, 1 mark for stating any of the negative aspects (of working from home) and 1 mark for discussion.*

Examples (Positive aspects):
Flexibility and agility
Increased productivity - due to fewer interruptions
Increased motivation
Autonomy
Improved health and wellbeing
Better work/life balance

Examples (negative aspects):
Working from home doesn't suit everyone
Employees feeling isolated
Home distractions
Negative impact on mental health
Not all jobs suit home working

***Note**: When a change to the work pattern is identified it can be an advantage or a disadvantage. For example, working at home can improve interaction with the family but also provide a distraction to work.*

12. (a) *Award **[2 max]***

Predetermined size (size should be known in compile time / it should be known in advance how many elements are to be stored in array);
Fixed size (once the memory is allocated to the linear array, it cannot be increased or decreased);
An array holds elements that have the same data type;
Array name represents the address of the starting element, all elements of an array can be distinguished using an index number (direct access to each element);
Array elements are stored in subsequent memory locations;

(b) *Award **[2 max]***
Linear/sequential search;
Binary search;

***Note**: Award other suitable responses such as Jump search, Interpolation search, Exponential search, etc.*

(c) *Award **[5 max]***
*Award **[1]** for the input of X and initialization of all variables used*
*Award **[1]** for a correct loop*
*Award **[1]** for checking if ROOMNUMS[K] is equal to X*
*Award **[1]** for changing the value of FLAG/FOUND*
*Award **[1]** for correct if statement after the loop*
*Award **[1]** for outputting both appropriate messages*

***Note:** The binary search is not acceptable, it will not work in this situation because the ROOMNUMS array is not sorted.*
***Note**: The sub-program heading may not appear.*
***Note:** For the loop accept either 0 to 9 (as question paper) or 0 to 999 to match array capacity*

Example 1

```
check(ROOMNUMS)
    input X
FOUND=false
    K=0
    loop while K<=9 and not FOUND
        if ROOMNUMS[K]=X then
            FOUND=true
        end if
        K=K+1
    end loop
    if FOUND then
        output('The student in the room', X, 'has paid the bill')
    else
        output('The student in the room', X, 'has not paid the bill
yet')
    end if
end check
```

Example 2

```
check(ROOMNUMS)
    input X
    FLAG=0
    loop K from 0 to 9
        if ROOMNUMS[K]= X then
            then FLAG=1
        end if
    end loop
    if FLAG=1 then
        output('The room No ', X,'- the bill paid')
    else
        output('The room No ', X,'- the bill NOT paid')
    end if
end check
```

(d) *Award **[6 max]***
Award [1] for correct outer loop
Award [1] for use of FLAG to stop loop when sorted
Award [1] for correct inner loop (e.g. iterating 0 to n-1 or 1 to n)
Award [1] for using an if statement inside the inner loop
Award [1] for correct comparison of adjacent elements in ROOMNUMS[]
Award [1] for correct swap

***Note:** The selection sort algorithm is not acceptable because the bubble sort algorithm is requested in the question paper.*

```
FLAG = true
loop while FLAG = true
    FLAG = false
    loop I from 0 to 8 //allow 0 to 998 limits
        if ROOMNUMS[I] < ROOMNUMS[I + 1] then
            TEMP = ROOMNUMS[I]
            ROOMNUMS[I] = ROOMNUMS[I + 1]
            ROOMNUMS{I + 1] = Temp
            FLAG = true
        end if
    end loop
end loop
```

***Note:** Limit could also be 1 to 9 / 1 to 999 with the check being* `ROOMNUMS[I + 1] > ROOMNUMS[I]`.