Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

November 2019

Computer science

Higher level

Paper 1

18 pages

Subject details: Computer science HL 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 75 marks.
Maximum total = 100 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]**.*

internet backup service could automatically back up (all important) data files;
to a remote server that could be accessed/controlled over the internet;

copies of all important data files (backup) could be placed on two separate hardware devices;
which are placed in two different physical locations;

a remote file server could be set up;
for uploading all important data files; **[2]**

2. *Award **[3 max]**.*

Cache memory is a memory that a computer microprocessor can access more quickly than it can access regular RAM;
It is integrated directly with the CPU chip or placed on a separate chip which has a separate bus interconnect with the CPU;
and stores frequently used data only until a computer is powered up;
Thus, when a processor requests data that already has an instance in the cache memory; it does not need to go to the main memory or the hard disk to fetch the data;

Cache memory is a small-sized type of volatile computer memory;
that provides high-speed data access to a processor;
and stores frequently used computer programs, applications and data;
Cache memory can be primary or secondary cache memory, where primary cache memory is directly integrated to the processor;
And secondary cache memory is a reserved portion on a disk stores and provide access to frequently accessed data/applications from the disk. **[3 max]**

3. (a) *Award **[1 max]***
Hexadecimal numbers are used for shorter representation of data because a (modern) byte can be represented exactly by two hexadecimal digits;
Hexadecimal numbers are used for shorter representation of data, because computers store and handle binary digits, and four binary digits make one hexadecimal digit; **[1]**

(b) *Award **[1 max]***
24; **[1]**

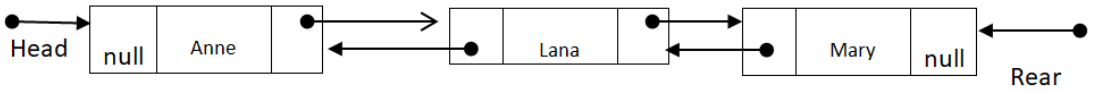
(c) *Award **[1 max]***
256 x 256 x 256 / $(2^8)^3$ / 2^{24};
256^3;
16 777 216; **[1]**

4. *Award **[4 max]***
*Award **[1]** for all 8 input values correct;*
*Award **[1]** for correct X column;*
*Award **[1]** for correct Y column;*
*Award **[1]** for correct Z column;*
Allow follow through from incorrect columns X or Y.

A	B	C	X	Y	Z
0	0	0	0	1	0
0	0	1	0	0	1
0	1	0	1	1	1
0	1	1	1	0	1
1	0	0	1	0	1
1	0	1	1	0	1
1	1	0	0	0	1
1	1	1	0	0	1

[4]

5. *Award **[3 max]***
*Award **[1]** for showing that every node in a double linked list contains three fields (data and 2 pointers);*
*Award **[1]** for showing every node has link to its previous node and next node/can be traversed forward by using next field and can be traversed backward by using previous field;*
*Award **[1]** for showing that the first node must be always pointed by an external pointer (for example head) (and the last node could be pointed to by an external pointer (for example rear));*
*Award **[1]** for showing that the previous field of the first node must be NULL and the next field of the last node must be NULL.*



[3 max]

6. Award ***[3 max]***

Abstraction allows us to create a general idea of what the problem is and how to solve it;
Abstraction removes all specific detail, and any patterns that will not help in solving a problem. This helps in forming a "model" (If designers don't abstract they may end up with the wrong solution to the problem they are trying to solve);
Abstraction is widely used because there exist a number of "patterns" in programming that keeps repeating in every application/program;
The pattern corresponding to an issue can be found, then the abstract solution to it can be found and implemented, and the problem is solved;
Most programming languages provide some built-in abstract patterns, which are easy to use (some API provides more advanced patterns);

Abstraction is the process of taking away or removing characteristics from something in order to reduce it to a set of essential characteristics;
In object-oriented programming, abstraction is one of three central principles (along with encapsulation and inheritance);
Through the process of abstraction, a programmer hides all but the relevant data about an object in order to reduce complexity and increase efficiency;
The resulting object itself can be referred to as an abstraction, meaning a named entity made up of selected attributes and behavior specific to a particular usage of the originating entity. Abstraction is related to both encapsulation and data hiding; **[3 max]**

7. *Award **[2 max]***

Virtual memory is a memory management capability of an OS;
that (uses hardware and software to) allow a computer to compensate for physical memory shortages by temporarily transferring data from random access memory (RAM) to disk storage; **[2]**

8. *Award **[5 max]***

*Award **[1]** for a trace table with at least three columns (headings K, N, M, K<5 and output);*
*Award **[1]** for each correct output up to **[4 max]***

K	N	M	K<5	OUTPUT
1	1	2	TRUE	1 2
2	3	4	TRUE	3 4
3	5	8	TRUE	5 8
4	7	16	TRUE	7 16
5	9	32	FALSE	

[5 max]

Section B

9. (a) *Award **[2 max]***
User roles / the organization restructure their workflow;
Technology issues / issues of software compatibility / hardware compatibility; **[2 max]**

(b) *Award **[5 max]**.*
Direct changeover:
is the cheapest and quickest/the old system is completely switched for the new one;
this is straight forward but also the most risky / nothing to fall back on;
no need to keep data duplicates;
it allows the organization to change the system when most convenient;
the employees have very little time in order get use to the new system as the change is instantaneous;
there is a period of time when neither systems are operational;

Phased conversion:
method where the old system is still in use but parts of the new system or modules are introduced, involves bringing in the new system one step at a time;
less risky than direct changeover; less risky that the whole system will go wrong/if something happens, it will only affect the specific part;
takes a lot of time;
employees have enough time for training/to get use to the new system / are introduced to the changes in small stages;
Employees/users could ask for changes which then hold up the installation of the next phase which helps improving the system; **[5]**

(c) (i) *Award **[1 max]**.*
User acceptance test;
Beta testing; **[1 max]**

(ii) *Award **[3 max]**.*
Can lead to software which is not appropriate for the purpose it was intended/can lead to the system not meeting user requirements;
Can lead to (undiscovered) bugs in software/errors in the system;
Can lead to end user dissatisfaction;
Can lead to reduced (employee) productivity;
Can lead to decreased reliability of the organization; **[3 max]**

(d) *Award **[4 max]**.*
Personal/professional development of all employees must be considered;
Physical safety (of all users);
Ergonomic standards (human-computer components);
Human dignity of all users;
The new system might be designed to replace some staff;
Code of ethics (system resources should not be used without approval); **[4 max]**

10. (a) *Award **[4 max]**.*
File sharing/resource sharing;
instead of using a disk or USB key to carry files from one computer to another, files can be shared directly using a network/all computers in the network can share resources such as printers, scanners;

Communication;
students/teachers can communicate with people around the world via the network;

Interactive teamwork;
software (like Microsoft Office) enables many users to contribute to a document concurrently;

Flexible access;
network allows students to access files from different computers (throughout the network) (one can begin work on a project on one computer and finish up on another);

Software cost;
software products are available for networks at a substantial savings in comparison to buying individually licensed software;

Software management;
load software on the server saves time compared to installing and tracking files on independent computers/upgrades are also easier because changes only have to be done once on the file server instead of on individual computers;

Improved network security;
if the school has its own network, it can monitor network traffic / can create a security culture (everyone who has a username and password is responsible for keeping data secure);

*Mark as **[2]** and **[2]**.* **[4 max]**

(b) (i) *Award **[2 max]**.*
A network router is a hardware device that is connected to multiple channels for different networks;
through an interface that is situated on each network;

Router acts as a processing unit for information packets;
it duplicates information packets for use during transmission from one network to another;

The router uses a protocol or set of rules;
to determine which information packets are to be routed to certain interfaces within the network; **[2 max]**

(ii) Award ***[2 max]**.*
Network interface cards are used to connect each computer to the network;
so they can communicate with the network router to receive information packets;

Interface cards determine the infrastructure of a local area network (LAN);
and allow all of the computers to connect to the network; **[2 max]**

(c) *Award **[2 max]**.*
Protocols define the rules that govern network communication (for example, packet format, type and size, what happens when an error occurs, and which part of the network is supposed to handle the error and how);

Computer networks consists of various types of equipment (such as routers, switches, hubs and network interface cards) and the equipment comes from different vendors, but they must all work together or the network does not operate correctly;

Protocols work in layers (the highest being what the user sees, and the lowest being the wire that the information is transferred along) and these layers communicate with each other according to the rules (allowing communication to occur accurately and efficiently); **[2 max]**

(d) *Award **[1 max]**.*
Data encryption refers to calculations/algorithms that transform plain text into a form that is non-readable to unauthorized parties (authorized recipient of an encrypted text uses a key and the algorithm to decrypt the data/ to transform it to the original plain text version); **[1 max]**

(e) *Award **[4 max]**.*

Each (wireless network) adapter has a unique label called a MAC address;

Routers uses these addresses to identify/authenticate computers (routers include an option to whitelist or blacklist certain devices based on MAC addresses, so access could be restricted to any device which is not in the whitelist);

One disadvantage is that the whitelist should be amended any time a new device is purchased / when access to guests should be granted;

Also this method is useless against hackers who use programs which intercept data passing through network and report the MAC address of any device communicating on the network; **[4 max]**

11. (a) (i) *Award **[1 max]**.*
Screen resolution is the number of pixels a screen can display (horizontally and vertically). (For example, the screen can show 1024 pixels horizontally and 768 vertically); **[1]**

(ii) *Award **[4 max]**.*
Screens that are different sizes (for example, 3–6 diagonal inches for a phone, and 9–12 diagonal inches for a tablet, size of 13–17 inches for a notebook screen, and a desktop screen size of 20–30 inches);
can still have the same screen resolution (for example, a laptop could have a 13-inch screen with a resolution of 1280 x 800 and a desktop computer could have a 17 inch monitor with the same 1280 x 800 resolution);
but physically smaller screen will not show less of the website;
the screen with the higher resolution will be able to show you more of the website because that screen has more pixels and the image will be sharper;
but elements on the screen (icons and text) will look smaller;

Most mobile displays currently have screens with fewer pixels than desktop displays and are physically smaller;
typing on small on-screen keyboards is difficult;
less precision (clicking a 12-pixel-high text link with a mouse is no problem but tapping the same link with fingers could be difficult);
there is no mouse pointer so there is no concept of "hovering" over a page element/ remaining in an uncertain state;
most modern touch screens allow zooming;
allow the user to perform gestures using one or more fingers, such as swiping/pinching;

***Note**: Award marks not only for issues for a viewer but also for issues for a creator of the interface.* **[4]**

(b) *Award **[4 max]**.*
OS controls all the activities of computer system and acts as an interface between user and hardware;

Thus the role of OS is
to keep track of who is using which resource;
to grant resource requests;
to mediate conflicting requests from different users/programs;
to allocate time to different programs or different users/ each one gets their turn to use that resource (for example printer);
to allocate space for different users, each one gets a part of the resource (for example sharing main memory/ hard disk); **[4 max]**

(c) *Award **[6 max]**.*
*Award **[2 max]** for evidence that:*
Sensors (input devices) detect/measure the water level;
sensors detect/measure the temperature (of the water);
sensors detect/measure the dampness/moisture level of the clothes;
sensors also detect movement of the machine's drum and other associated actions;

Sensors continuously take readings/measurements (in the context of above) and send these readings to the processor;

*Award **[2 max]** for evidence that:*
processor controls sensors, valves and actuators responsible for controlling the parts that clean clothes;
processor determines what actions the machine should take next;
the washing machine has been programmed/ it goes through a process of running its internal programs;

processor compares readings with pre-set values (in the context of the various sensors);
if the readings fall outside of the specified range, the processor sends a message to the output transducer to switch on/off ... (in the context of part of the washing machine);

*Award **[2 max]** for evidence that:*
output transducers are used for turning on and off devices that control the rest of the machine;
such as the motors that spin the tub;
or the water pump;

Example:
once the start button is pushed the washing machine begins to dump water into the drum, a sensor will detect that the water level has been reached;
based on the setting, the processor will allow the water to flow only to a predetermined level;
it will send the signal to output transducers to shut off the water;
and begin the agitation process;
once the timer tells that it is time, processor sends signal to output transducer to stop agitating;
it then begins the spin process/ removing the dirty water from the machine
at the end of the spin cycle, the washing machine's processor sends signal to turn on the water pump and sucking it out of the machine; **[6 max]**

12. (a) *Award **[2 max]**.*
Holding all data of a function/method call; simulation of recursion;
Conversion of expressions (infix to postfix, infix to prefix, *etc*)
Evaluating expression;
Parsing; **[2 max]**

(b) *Award **[6 max]**.*
*Award **[3 max]** for the following:*
An array A of N elements should be initialized (fixed, predetermined size);

[0]	[1]	[2]	. . .	[N-1]
Value0	Value1	Value2	...	

keep track of the top of the stack since not all of the array holds stack elements (in an integer variable, for example, named TOP);

the main property of a stack is that stack values/objects go on and come off of the one end of the stack (LIFO data structure);

*Award **[1]** for each stack method outlined.*

Push
Places a value (object) on the top of the stack;
Increase TOP by one and set A[TOP]= value;

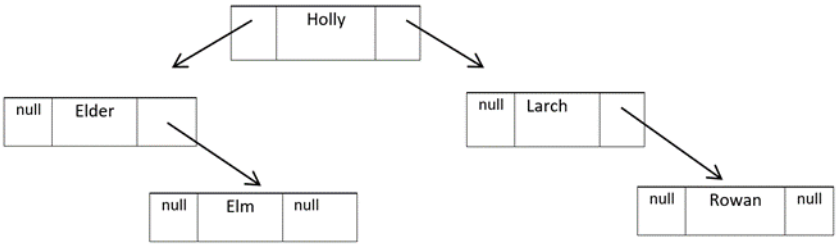
Pop
Returns a value from the top of the stack and removes that value from the top of the stack;
Returns A[TOP] and decreases TOP by 1;

IsEmpty
Reports whether the stack is empty or not / returns True if the stack is empty, False otherwise;
Returns True if TOP is less than 0, False otherwise;

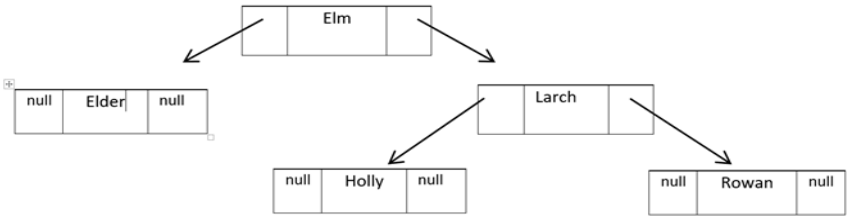
IsFull
Reports whether the stack is full or not/ returns True is stack is full, False otherwise;
Returns True if TOP is greater than N-1 (where N is size of the array), False otherwise; **[6 max]**

(c) (i) *Award **[1 max]**.*
The names must be in the following order:
Elm, Elder, Holly, Rowan, Larch, Hazel; **[1]**

(ii) *Award **[3 max]**.*
*Award **[1]** for the correct root.*
*Award **[1]** for the correct left subtree.*
*Award **[1]** for the correct right subtree.*



OR



[3 max]

(d) *Award **[3 max]***
Static data structures are fixed sized (for example, arrays) whilst dynamic data structure (for example, trees, linked lists) have flexible size;

The size of static data structures is predetermined; the amount of memory once allocated to them at compile time cannot change on run time whereas dynamic data structures they can grow or shrink as needed to contain the data to be stored;

Slower access to elements of dynamic data structure (sequential access) when compared with (direct) access to elements of static data structures; **[3 max]**

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

(b) *Award **[8 max]**.*
*Award **[1]** for initialization, correct changing and returning of a flag.*
*Award **[1]** for the nested loops.*
*Award **[1]** for correct initial and for correct terminal value and changing the value of the control variable in **outer** loop.*
*Award **[1]** for correct initial and for correct terminal value and changing the value of the control variable in **inner** loop.*
*Award **[1]** for **efficiency** (terminating execution when a zero or non-zero element is not at the correct position).*
*Award **[1]** for correct condition in if statement.*
*Award **[1]** for checking elements in the lower/upper triangle.*
*Award **[1]** for checking elements on the three diagonals.*
*Award **[1]** for the correct logical expression.*

Example 1:

```
INVALID=False
R=0
loop while R<N and not INVALID
   C=0
   loop while C<N and not INVALID
      if abs(R-C)>=2 and A[R][C]!=0 or abs(R-C)<2 and
A[R][C]==0 then
         INVALID=True
      endif
      C=C+1
   endwhile
   R=R+1
endwhile
return not INVALID
```

Please note that instead the logical expression given in the Example answer 1 several if statements could be used and award 1 mark for each correct if statement (1 mark for checking elements in the lower triangle, 1 mark for checking upper triangle, 1 mark for checking three diagonals).

```
if R>C and R-C>1 then   //lower triangle
   if A[R][C]!=0 then
      INVALID=True
   endif
endif
if R<C and C-R>1 then   //upper triangle
   if A[R][C]!=0 then
      INVALID=True
   endif
endif
if R<C and C-R=1 or R>C and R-C==1 or R==C then   //three
diagonals
   if A[R][C]==0 then
      INVALID=True
   endif
endif
```

Example 2:
*Award **[7 max]** (no 'efficiency' mark).*
*Award **[1]** for initialization, correct changing and returning of a flag*
*Award **[1]** for the nested loops.*
*Award **[1]** for correct initial and for correct terminal value of the control variable in **outer** loop.*
*Award **[1]** for correct initial and for correct terminal value of the control variable in **inner** loop.*
*Award **[1]** for correct condition in if statement.*
*Award **[1]** for checking elements in lower/upper triangle.*
*Award **[1]** for checking elements on the three diagonals.*
*Award **[1]** for the use of correct logical expressions.*

```
INVALID=False
loop R=0 to N-1 do
   loop C=0 to N-1 do
      if abs(R-C)>=2 and A[R][C]!=0 or abs(R-C)<2 and
      A[R][C]==0 then
         INVALID=True
      endif
   endloop
endloop
return not INVALID
```

[8 max]

(c) *Award **[4 max]**.*

```
X = mystery( MAT, 5)= 5+ mystery( MAT, 4);
5 + 7 + mystery( MAT, 3);
5 + 7 -5 + mystery( MAT, 2);
5 + 7 -5 + 9 + mystery( MAT, 1);
5+7-5+9+1+mystery(MAT, 0)= 5+7-5+9+1+0 = 17;
```

[4 max]

(d) *Award **[2 max]**.*

Calculates the sum of R elements;
Starting from A[R][R-1] to A[1][0];
on the sub-diagonal (of the two-dimensional array A); **[2 max]**