

Markscheme

May 2025

Computer science

Higher level

Paper 1

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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 **max** [2].
GUI components (tabs, buttons, scroll bars, icons, pointers, windows);
Toolbars;
Menus;
Dialogue boxes;
Simplicity;
Intuitiveness / user friendly/ intuitive and easy to use;
Consistency;
Clarity;
Attractiveness;
Responsiveness;
Familiarity;
Accessibility;
Efficiency
Customization;
Note: Reward other correct answers.

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

Award [1] for a function/purpose and [1] for a reasonable expansion.

to store data permanently (even if the power supply is off);
So, it can be accessed at a later time;

to provide large storage;
can store large files (like videos, images, audios, files, etc.) permanently;

to store/transfer data from one computer to another;
removable secondary storage devices can be easily disconnected and used on different systems;

to back up important data;
data backups used for disaster recovery due to system failure/accidental deletion;

to retain data;
beyond the capacity constraints of primary storage;

to enhance system performance/ allow the system to handle more tasks simultaneously;
by swapping data between RAM/primary memory and secondary memory/
Virtual memory;

to offer remote/online storage (cloud storage);
enabling users to access data/files from any device/collaborate easily across locations;

to store large databases (for businesses/science/research/education);
supporting data retrieval/management;

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

Primary memory required by all running processes exceeds the volume of RAM installed (shortage of physical memory);

A program currently used is too large to fit into the RAM (*Accept a description, such as attempting to play a video game which is much bigger in size than the RAM, when editing a large video file in specialised software*);

Part of the program (inactive pages) that is not currently being used can be stored in secondary memory temporarily / until it is required;

Note: *Terms like virtual memory, segmentation, paging may be used.*

3. Award **max** [4].

Award [1] for a hardware upgrade and [1] for an expansion/description of improvement, x2.

Upgrade processor (resulting in faster processor or more cores);

To increase the speed of execution/ efficiency of the computer/ make the browser more responsive;

Add more RAM;

allows faster access to/use of memory-intensive applications (*Accept examples such as graphic software, etc.*);

Upgrade storage/increase the hard disk/SSD size;

get a faster drive with more storage space/ more reliable storage devices;

Replace the graphic card with a new one;

So that colourful images on the monitor are of better quality;

Upgrade peripherals;

to have full support for the electronic devices / to increase efficiency of the computer;

Note:

Reward other reasonable answers such as upgrade CPU cooling system (which prevents overheating, allowing components to run at optimal speeds), upgrade expansion cards (Network adapter, Wireless network adapter and so on).

Accept examples, such as:

Upgrade I/O devices (keyboard/mice/scanner/display, etc.);

newer/faster/efficient I/O devices can impact the overall performance of the computer;

replace the old monitor with a new one;

to improve display quality (colour accuracy, etc.).

4. Award **max** [4].
Award [1] for an advantage and [1] for a description, **x2**.

Cost effective/ flexible way of gathering data;
from large number of users/ surveys can be sent out as offline or online form (for better reach);

Fast way of gathering data;
data from a large number of users can be collected in a short period of time;

Standardized question formats;
can yield more reliable data than other methods (interviews, observation, etc.);

Anonymity/ privacy for respondents;
can lead to more honest responses;

Simple to administer (less time consuming than other methods);
A large amount of data gathered in a short period of time;

Fast results/ easy to extract quantitative data/ easy to analyse data;
because all the users are asked the same questions;

Note: Reward other correct responses.

5. Award **max** [4].
Award [1] for every two correct rows.

A	B	C	X
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	1

6. Award **max** [2].

Parallel running;
Pilot running;
Direct changeover (Big-bang method);
Phased conversion;

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

contains a database of public IP addresses and their associated hostnames/domain names;
translates/matches those website hostnames to their corresponding IP addresses;

translates human-readable domain names (like www.ibschool.com) into machine-readable IP addresses (like 2001:0db8:85a3:1111:0000:8a2e:0380);
allows users to access websites by using meaningful names (instead of IP addresses which are difficult to remember) /presents the corresponding web page of the domain name entered by the user;

acts like a directory of web servers on the internet;
lets web browsers connect to the web servers;

converts human-readable domain names into IP addresses;
ensures that internet traffic reaches the correct destination based on the domain name;

Note: Reward other correct responses.

8. Award **max** [3].

Award [1] for a reason/example/scenario where VPN is relevant.

Award [1] for a feature of VPN (encryption, tunnelling, leak protection, data or bandwidth caps, zero-logs policy, IP shuffling, kill switch). (Accept either a term/name or a description of a feature.)

Award [1] for an elaboration.

Note: *The reason/example/scenario, feature and elaboration must work as whole coherent answer. The following answers are only examples there could be other appropriate answers.*

Employees may use a VPN to access company's network/internal resources/databases/ from a remote location:

VPN creates a tunnel;

allowing secure connections and access (based on employees' roles);

Users who need a secure/private communication may use VPN;

VPN encrypts data;

and prevents hackers from intercepting sensitive information;

Users of insecure public Wi-Fi/ safer browsing while on public Wi-Fi;

logging in on their socials/ purchasing something online/ leaving credentials;

VPN lets connect to the provider's servers creating a private tunnel that secures data;

Users may use a VPN to give themselves more privacy/ anonymity online/ avoid geographical limitations;

IP address is masked so the location of the user is not known;

So they can visit websites that are restricted by location/ online businesses use geographic segmentation which means prices of product that can be bought and sold (books, airline tickets, clothes) vary depending on the buyer's location/ may be essential if a country is likely to block internet content from foreign entities, for example, journalists could use a VPN to look like they are within that country (*Accept any legitimate reason for needing to be unknown*) ;

Use of a VPN during days and times when a lot of people trying to stream content and download files at the same time / to avoid congestion (during peak times of internet usage);

With a VPN user can choose what network their traffic travels on;

So, VPNs can (sometimes even) increase the internet speed;

VPNs can be used for bypassing network restrictions;

to access certain blocked websites;

VPNs can tunnel around the restrictions;

Internet/social media users (streaming, online gaming, etc.) may use VPN to avoid tracking/surveillance;

because VPN hides the type of traffic;

and it can prevent the risk of getting frequent advertisements/ the risk of bandwidth throttling (slowing down) by ISP provider;

Section B

9. (a) (i) Award **max** [1].

software used (by designers) to create 2D/3D models of physical components/software used to simulate hand drawn sketches of component parts of an entity (machine, vehicle, etc.);
software that is used to create / modify / analyse / enhance a design;

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

Award [1] for a benefit and [1] for a reasonable expansion, x2.

Increased productivity;

CAD software automates most of the architect's tasks which allows quicker project completion/ the same amount of time can result in a greater number of completed projects;

Flexibility to modify designs;

Allows for changes and revisions to be visualized and approved;

Decreased architect's effort;

the different parts of code and drawings can be modified easily then reused multiple times;

Saves time;

Easy/quick to create/edit/ make alterations in the drawings;

Saves cost/money;

a model could be created using CAD, and modified before the structure/product is produced (if it does not work, it could cost the architect more money to create again);

Better quality of drawings/ realistic designs/ better visualization of the product;

The CAD makes use of best tools (that allow creation of precise complex drawings of surfaces and shapes);

Improved accuracy;

CAD tools include many mathematical equations that perform vital calculations/examine curves/surfaces;

Fewer errors;

the CAD software makes use of tools to investigate an error, diagnose the problem, and solve it;

Easy to share work with colleagues/clients;

The CAD tools make it easier to save the files and store it in a way that they can be used again and/or sent;

Integration with other tools;

CAD designs can be given to a 3D printer or CAM for direct implementation;

Note: Reward other reasonable responses.

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

To reduce the size of files;
so that less memory space on the architect's computer is occupied/ more CAD files can be stored in the available memory;
faster upload/download/ transmission time reduced/ improved data transfer speed;
easier to meet attachment size restrictions/ reductions in communication bandwidth (capacity for the data transfer):
meaning a significant decrease in expenses;

- (c) (i) Award **max** [3].

*Award [1] for a reasonable method;
Award [1] for indicating how downtime is minimized;
Award [1] for indicating how data is made available;*

Example answers:

A regular/periodical back up;
stored on external storage devices;
data could be quickly recovered;

A secondary system/ a standby computer (or only duplicate disks and a processor);
with an appropriate backup system;
that might take over, with data quickly restored to the last point it was backed up;

A failover system/RAID;
that automatically takes over;
with no data loss;

in case of a hard drive failure not all of data is erased/damaged;
the architect can (buy and) use a data recovery software/ hire a skilled data recovery service;
this will enable recovery of as much data as possible, but it takes time;

Cloud Storage/ the architect can save/back up all files to the cloud (*Accept examples, OneDrive, Google Drive, etc.*);
and can access them from any device/anywhere;
anytime/when required/when disk fails;

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

Award [1] for a cause and [1] for a reasonable expansion, x2.

Human errors;

Data may be accidentally deleted/ entered/ altered inaccurately/ files may be wrongly replaced/ files might not be saved;

Transfer errors;

Data may be lost in transit between two systems (such as a network failure, network congestion, incorrect storage destination, between two physical locations- transporting a backup / storage device to another location);

Computer viruses/ malicious acts/ malware/ hacking;

Can steal/ alter/ destroy data;

Software malfunction;

an application used for requesting/editing data can crash resulting in data loss;

Natural disasters (for example, floods, earthquakes, hurricanes, cyclones, fires, lightning); that can damage on-premises software/hardware and lead to data loss;

Power failures;

can damage operating system resulting in data loss;

Disk full / no available space on the disk;

prevents new (or updated) data from being saved leading to data loss;

Lossy compression;

compressed file is not restored/rebuilt to its original form;

Note: *Reward other reasonable responses.*

10. (a) Award **max** [6].

Example 1:

Each user should be assigned a user role (administrator, student, teacher, guest);
Each user must have a unique username and password;
Different access levels could be implemented by using password/ authentication (PIN/ token/ biometrics/ two-factor authentication (2FA) before accessing a file/ through whitelisting/blacklisting devices/ by verifying MAC addresses;
Users assigned an administrator role have full access to the system/ are allowed to perform most operations on the system (such as, add, remove, edit users, groups, domains, manage passwords, configure services, etc.);
Users assigned a teacher role have read-write access to update student grades/ read-only access to students' records/ no access to other teachers' financial records;
A user assigned a student role has read access to their reports / no access to other students' /teachers' data;
A user assigned a guest role has restricted/limited access to certain file/folders/information / no access to the files with sensitive or personal data/ users with guest accounts can only read from files containing general information/ guest users cannot perform any actions/ guest users can only browse the internet);

Example 2:

Create a Virtual Local Area Network (VLAN) that allows segmentation of different user groups;
Each VLAN uses strong authentication/ user logins /two-factor authentication;
Each VLAN can have specific security policies/ rules and restrictions;
Implement Access Control Lists (ACLs) on devices/ define what resources each group of users can access/ assign permissions based on user roles (RBAC);
Administrators have full access to all resources;
Teachers have access to their personal records/teaching materials/authorized student data;
Students have access only to their own files/ assignments/ reports / no access to others' data;
Guests have internet access only/ restricted access through firewall and ACLs / no access to sensitive information;

Example 3:

Intranet and extranet could be implemented;
The intranet is restricted to group of users related to the school (administrator/teachers/students);
Each teacher/student has login, password (and permissions);
Administrators have full access to all resources (intranet and extranet);
Teachers have access to their personal records/teaching materials/authorized student data;
Students have access only to their own files/ assignments/ reports;
Extranet is accessible to all (administrator/teacher/student/guest) / Extranet provides limited access from outside the LAN for all users working remotely;
Guests have access to Internet;

- (b) (i) *Award **max** [2].*
Award [1] for a communication link and [1] for a reason/ justification.

Fibre-optic cable;
Because data transmission is fast/ reliable;

Coaxial cable (Cable internet);
Because it is (still) one of the fastest internet types / is significantly faster than DSL/
practical because it uses the same coaxial connections as phone services/ cable TV;

5G wireless broadband/mobile internet;
Because of greater speed in the transmissions/ a greater number of connected devices/
the possibility of implementing virtual networks;

Satellite link;
higher data transmission rate/ better coverage;

- (ii) *Award **max** [4].*
*Award [1] for a security measure and [1] for justification, **x2**.*

Enable firewalls;
To monitor/prevent unauthorized access to the network/ to alert network administrators to
any intrusion attempts/ to monitor all the incoming and outgoing traffic of the school
network/ to set the rules to blacklist certain websites;

Router/access point can be configured;
to allow only pre-approved MAC addresses (approved by network administrator) to
connect to the network/ whitelist/blacklist filtering;

Fibre optics;
To reduce the chances of interception/ more challenging for hackers to intercept;

Install new updates/ enable automatic updates (OS/firmware/apps, whenever/wherever
possible);
to ensure running the latest/most secure versions;

Use encryption;
if cybercriminals gain access to the network, encryption prevents them from
reading/understanding any of sensitive information;

Install an antivirus program on all computers;
run or schedule regular virus scans to keep computers virus-free;

Install anti-spyware software;
that records/prevents/removes every attempt/keystroke to gain access to passwords/
other sensitive information;

Train/educate users (teachers, students);
to use complex passwords/ to update passwords on regular basis/to ignore email
messages from unknown parties and never click on links or open attachments;

Use multi-factor authentication (MFA)/ two or more different types of actions to verify
identity;
to defend against the threat of password-related cyberattacks;

Use of VPN;
ensures secure access through encryption / tunnelling;

A captive portal/ implement an authorisation online portal;
Newly connected users should enter password/user ID before they are granted access to network resources;

Note: Do not accept backup as a method as it does not prevent the threat.

Note: Reward other reasonable responses.

(c) Award **max** [3].

emails may fill the storage available;
emails may overload the internet connection/ emails with larger file transfer can utilize a lot of network bandwidth;
phishing attacks/ potential data leak-students click link in emails/visit an infected website;
downloading of viruses or worms from emails corrupting the whole network;
if email accounts are compromised, attackers could gain access to school systems/ distribute malware across the network;
inappropriate messages may be sent within/ outside the school/students may use it for bullying;
e-mail messages could be used to cheat on exams/ assignments;
teachers/ students may become vulnerable to email from strangers/ a risk of sending/receiving offensive/ inappropriate/ harmful content through email;
inappropriate use of school email for personal communication;
many email accounts can increase the workload for IT staff/ more IT support/ monitoring/ maintenance needed;
increased costs (for licensing, email server, etc.)

Note: Reward other reasonable answers.

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

An embedded system is a microprocessor/ controller-based system within a larger system or device;
which is designed to perform a specific task / can be programmable/ have a fixed functionality;

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

Industrial machines;
Household appliances;
Automobiles/airplanes;
Medical equipment;
Digital watches;
Cell phones;
Toys;

Note: Reward other reasonable answers.

- (b) Award **max** [4].
Award max [2] for pros and max [2] for cons.

Pros:

Better control over traffic flow/ any problem appearing at one traffic light is known immediately/ can be dealt with immediately;
Traffic lights can be quickly adapted to avoid traffic blocks/ when levels of traffic flow change;
All traffic lights can be synchronized efficiently, allowing smooth traffic flow across the city (e.g., creating green waves on main roads);
Easier to add additional hardware/ inputs such as sensors;
Cheaper-reduces the need for separate hardware (controllers or advanced systems) at each intersection/ cheaper maintenance;
Centralised data collection (accidents, traffic) that could help with future planning;
Control program can be done at one place, with different programs for different times of day and related traffic patterns;
easier maintenance/software updates can be performed centrally without having to make adjustments at every intersection;

Cons:

single point of failure - failure of the central computer stops the entire city's traffic system;
system depends on high-speed communication links, network failure can disrupt activity;
the capacity/speed of the central computer can be limited/cannot provide the desired levels of service (many inputs with differing priorities which could take time);
high initial cost of communication system/central control system/software;
security risks/cyberattacks on the central computer affects the entire city;
reduced local autonomy/ individual intersections cannot make local decisions like dealing with an unexpected blockage/ emergency;
difficult to scale up as the city expands (system may struggle to handle increased load) /
disruption in service/ increased complexity in decision-making and processing;

Note: Reward other reasonable benefits and drawbacks.

- (c) Award **max** [2].

Motion sensors;
Pneumatic tubes;
Piezoelectric sensor;
Inductive loop;
Magnetic sensors;
Acoustic detectors;
Infrared detectors/sensors;
Doppler sensors;
Radar/microwave/ultrasonic sensors;
Pressure sensors;
Image sensors;
Radio frequency sensors;
Proximity sensors;

Note: Reward other correct answers.

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

Interrupt can occur at any point in time (an interrupt is asynchronous);
processor polls the devices at regular intervals of time (polling is a synchronous activity);

Interrupt occurs only when a device requires servicing;
Polling occurs when processor needs to wait and check if a device needs to be serviced/
processor continuously checks the status of the device to find whether it requires attention;

Interrupts save the processor cycles;
polling wastes many of the processor cycles;

Interrupts are priority based;
Polling involves sequential checking with no priority;

Interrupts allow the CPU to respond quickly to a situation;
Response may be delayed depending on polling order / frequency;

Polling involves creating a software loop (to regularly and continuously read sensor data);
Interrupt is a hardware mechanism (in which the sensor notices processor that it requires its attention);

- (e) *Award **max** [3].*
 Award [1] mark for benefit,
 Award [1] for situation/example
 Award [1] for elaboration/justification

Example answers;

to reduce accidents/ improving safety;
by optimizing flows across intersections;
during periods when roads are shut down due to construction/ any other events;

enables the optimization of traffic flow;
saving time/ fuel/cost;
which is of great benefit for taxi drivers, logistics providers, on-demand services such as food delivery;

early warnings about traffic incidents;
improve driver safety/ save lives;
a quick passage to emergency vehicles (ambulances / fire tenders) can be facilitated;

providing traffic advisories/ alternative route diversion;
improve drivers' comfort;
which means less stress/ less traffic accidents;

insights into congestion/delays across the city road network;
enable traffic management authorities to create smarter mobility solutions;
that reduce pollutant emissions that can cause respiratory problems/other health issues;

insights into congestion/delays/traffic accidents;
allows drivers to delay or prepone the trip (based on current traffic trends);
plan the departure time more effectively;

Note: *Reward other reasonable answers.*

12. (a) Award **max** [5].
Award [1] for each correct recursive call shown, **x5**.
Award [1] for the correct result.

```

x = recfn(5) = recfn(4) + 5 ;
    = recfn(3) - 4 + 5 = recfn(3) + 1 ;
    = recfn(2) + 3 - 4 + 5 = recfn(2) + 4 ;
    = recfn(1) - 2 + 3 - 4 + 5 = recfn(1) + 2 ;
    = recfn(0) + 1 - 2 + 3 - 4 + 5 = recfn(0) + 3 ;
    = 0 + 1 - 2 + 3 - 4 + 5 = 0 + 3 = 3 ;

```

Note: The working may be shown differently.

- (b) Award **max** [4].
Award [1] for name and [1] for description of operation, **x2**.

Push;
Add an element to the top of a stack;

Pop;
Remove an element from the top of a stack;

IsEmpty;
Check if the stack contains no elements/ returns True when a stack is empty, returns False otherwise;

IsFull;
Check if the stack has reached maximum capacity/ returns True when a stack is full, returns False otherwise;

(c) Award **max** [6].

Award [1] for correct initialization (before the loop)

Award [1] for correct loop through the NUMBERS stack using isEmpty()

Award [1] for taking an element from the top of the NUMBERS stack using pop()(within the loop)

Award [1] for changing the value of SMALLEST if needed

Award [1] for changing the value of LARGEST if needed

Award [1] for placing SMALLEST and LARGEST on the stack NUMBERS using push() (after the loop)

Award [1] for the order of push operations: first push LARGEST onto the stack then SMALLEST (so that SMALLEST will be on the top of stack NUMBERS)

Example 1:

```
X = NUMBERS.pop()
SMALLEST = X
LARGEST = X
// OR
// initialization
// SMALEST= 999999999999 (any very large number)
// LARGEST= -999999999999 (negative number!)
loop while not NUMBERS.isEmpty()
    //searching for the smallest and largest value
    X=NUMBERS.pop()
    if X <= SMALLEST
        then SMALLEST = X
    else if X >= LARGEST
        then LARGEST = X
    end if
end if
end loop
NUMBERS.push(LARGEST)
NUMBERS.push(SMALLEST)
```

Example 2:

```
SMALLEST = NUMBERS.peek() //initialization
LARGEST = SMALLEST
loop while NUMBERS.isEmpty()= false
    //searching for the smallest and largest value
    X=NUMBERS.pop()
    if X < SMALLEST
        then SMALLEST = X
    end if
    if X > LARGEST
        then LARGEST = X
    end if
end loop
NUMBERS.push( LARGEST)
NUMBERS.push(SMALLEST)
```

13. (a) *Award max [3].*

The (difficult) program is divided into several easier parts (sub-programs);
 The program is better organized/ easier to understand /reduced size of code (due to several sub-programs calls)/ no duplication of code;
 Sub-programs hide implementation details;
 Sub-programs keep specific tasks self-contained;
 Each of the sub-programs could be written independently;
 Each of the sub-programs is debugged/tested independently;
 Different parts of the program can be written at the same time/concurrently;
 Sub-programs speed up the development process (as different students can work on different subprogram at the same time);
 Each sub-program could be used many times in this program (and in other programs);
 The maintenance/modification/change of the program will be easier/faster (because only a sub-program could be changed/modified as needed);

(b) *Award max [4].*

Award [1] for a correct while loop

Award [1] for a correct condition /validation check

Award [1] for input within the while loop (input repeated until input validated)

Award [1] for outputting appropriate messages

Award [1] for return statement;

Example 1:

```
inputInRange()
    K=input('Enter a number: ')
    loop while (K < 1) or (K > 25)
        output ('The number is not in the range 1 to 25. ')
        output(' Please try again! ')
        K=input('Enter a number: ')
    end loop
    output('Your number is valid. ')
    return K
end inputInRange()
```

Example 2:

```
inputInRange()
    F=true
    loop while F
        output('Enter a number')
        input(K)
        if(K < 1) or (K > 25)
            then
                output ('The number is invalid. ')
                output( 'Please try again! ')
            else
                F=false
            end if
        end loop
        output('Your number is valid. ')
        return K
    end inputInRange()
```

Example 3:

```
inputInRange()  
  
    loop while True  
        K=input('Enter a number: ')  
        if(K >= 1) and (K <= 25)  
            then  
                output('Your number is valid. ')  
                return K  
            else  
                output('The number is not in the range1 to 25. ')  
                output('Please try again! ')  
            end if  
        end loop  
    end inputInRange()
```

(c) Award **max** [8]

Example 1:

Award **max** [2] for initializing the *FLAGS* array. Award [1] for correct loop and [1] for correct assignment statement.

Award **max** [4] for matching up the values in the *MAT* array with indexes in the *FLAGS* array and assigning values to elements of the *FLAGS* array. Award [1] for correct row loop, [1] for correct column loop, [1] for calculating index, [1] for assignment statement.

Award **max** [4] for inspecting all elements in the *FLAGS* array and displaying appropriate messages. Award [1] for use of flag, [1] for correct loop through the array *FLAGS*, [1] for correct condition, [1] for correct flag test and appropriate output (after the loop)

Note: The subprogram heading and return statement may not appear.

isCorrectlyCompleted (MAT)

```
// the FLAGS array holds 25 zeros indexed from 0 to 24
// initializing the FLAGS array
loop K from 0 to 24
    FLAGS[K] = 0
end loop

// matching up the values in the MAT array with
// indexes in the FLAGS array
// and assigning values to elements of the FLAGS array
loop R from 0 to 4 // 4 or MAT.length-1
    loop C from 0 to 4
        INDEX = MAT[R][C]-1
        FLAGS [INDEX] = 1
    end loop
end loop

//inspecting all elements in the FLAGS array
//and displaying appropriate messages

F = true //searching for 0s in the FLAG array
loop K from 0 to 24 // 24 or FLAGS.length-1
    if FLAGS [K] = 0
        then F = false
    end if
end loop

if F // F==true
    then
        output('the table has been correctly completed')
    else
        output('the table has not been correctly completed')
    end if
return
end isCorrectlyCompleted
```

Alternative pseudocode for ‘initializing the FLAGS array’:

Award [2] for

```
FLAGS = [0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0]
```

Alternative pseudocode for the part “inspecting all elements in the FLAGS array and displaying appropriate messages”

```
k=0
loop while k <=24 DO
    if FLAGS[k] == 0
        then output('the table has not been completed correctly')
            return
        endif
    k = k+1
endloop
output('the table has been completed correctly')
```


Example 2:

Award **max** [8]

Award **max** [2] for initializing the *FLAGS* array. Award [1] for correct loop and [1] for correct assignment statement.

Award **max** [4] for matching up the values in the *MAT* array with indexes in the *FLAGS* array and assigning values to elements of the *FLAGS* array. Award [1] for correct row loop, [1] for correct column loop, [1] for calculating index, [1] for assignment statement.

Award **max** [4] for inspecting all elements in the *FLAGS* array and displaying appropriate messages. Award [1] for initializing counter, [1] for correct loop through the array *FLAGS*, [1] for increasing counter (if needed), [1] for correct test and appropriate output (after the loop)

```
//the FLAGS array indexed from 0 to 24
//initializing the FLAGS array

loop K from 0 to 24
    FLAGS [K] = 0
end loop

// matching up the values in the MAT array with
//indexes in the FLAGS array
// and assigning values to elements of the FLAGS array

    loop R from 0 to 4
        loop C from 0 to 4
            FLAGS [MAT[R][C]-1] = 1
        end loop
    end loop

//inspecting all elements in the FLAGS array (counting 1s)
//and displaying appropriate messages

COUNTER = 0 //counting 1s in the FLAG array
loop I from 0 to 24
    if FLAGS [I]== 1
        then COUNTER = COUNTER + 1
    end if
end loop

if COUNTER == 25 // all 1s in the FLAGS array
    then output('the table has been completed correctly')
    else output('the table has not been completed correctly')
end if
```

Example 3 (alternative):

Award **max** [8].

Award **max** [2] for initializing the *FLAGS* array: [1] for correct loop and [1] for assignment statement.

Award **max** [6] for matching up the values in the *MAT* array with indexes in the *FLAGS* array, assigning values to elements of the *FLAGS* array and for terminating the algorithm early:

[1] for correct row loop

[1] for correct column loop

[1] for calculating correctly index in the *FLAGS* array (index is **MAT**[R] [C] -1)

[1] for checking if the value of the *FLAGS* element at that index is 1

[1] for outputting that the table has not been filled in correctly (within the inner loop)

[1] for terminating early the execution of the algorithm (*return* within the inner loop)

[1] for assignment **FLAGS** [**MAT**[R] [C] -1] = 1 (if the *FLAGS* element at that index is 0)

[1] for output after the nested loops (outputting that the table has been filled in correctly)

```
// the FLAGS array holds 25 values indexed from 0 to 24
// initializing the FLAGS array

loop K from 0 to 24
    FLAGS [K] = 0
end loop

// matching up the values in the MAT array with
// indexes in the FLAGS array
// and assigning values to elements of the FLAGS array
// this algorithm outputs message and terminates immediately
// in case that a number (MAT[R][C]-1) appears for the second
// time in the FLAGS array (when FLAGS [MAT[R][C]-1] == 1)

loop R from 0 to 4
    loop C from 0 to 4
        if FLAGS [MAT[R][C]-1] == 1
            then
                output('the table has not been completed correctly')
                return
            else
                FLAGS [MAT[R][C]-1] = 1
            endif
        end loop
    end loop
end loop

// MAT completed correctly, displaying an appropriate message

output('the table has been completed correctly')
```
