M23/4/COMSC/HP1/ENG/TZ2/XX/M

Markscheme

May 2023

Computer science

Higher level

Paper 1

26 pages

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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*.

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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* ***[2 max]***

print queue (serving requests on a shared printer) / spooling in printer;
CPU task scheduling;
handling of interrupts (in the same order as they arrive);
buffer for devices like keyboard;
queues in routers/ switches;
mail queues;
simulation/ computer modelling of physical queues (e.g., a customer waiting line in a supermarket queue, a call centre where technical personnel take calls and provide service, etc.);
handling website traffic/ network congestion;
maintaining playlist in media player;

Note*: Accept other appropriate examples of applications of queues in computing.*

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);

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

(Software) interrupt is a signal emitted by software (when an application program terminates/ requests certain services from the OS/ a process (or an event) needs immediate attention;

(Hardware) interrupt is a signal created by some action taken by a hardware device and sent to the CPU to stop its current activity;

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

*Award **[1]** for CPU checking status of each sensor to see if it needs attention*
*Award **[1]** for identifying/ sampling their status by a program (running on the computer)*
*Award **[1]** for operating at the same periods of time*
*Award **[1]** for relation to given situation*

The computer could continually interrogate all connected sensors along the river;
to identify if their status has changed/ they require to transmit data;
the readings from each sensor along the river could be taken at regular intervals;
in an order determined by the program running on the computer/ at a frequency determined by the program running on the computer;
ensuring that the frequency of polling increases in the parts of the river where the measurements are deemed to be higher/ in specific times when the quality of the water is known to be worse/ in times of lower use of the (central computer) processing units;

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	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

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;

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7. *Award* ***[2 max]***
Award ***[1]*** *for each comparison up to* ***[2]****.*

RAM is a volatile memory (which could store the data as long as the power is supplied) whilst ROM is a non-volatile memory (which could retain the data even when power is turned off);
Data stored in RAM can be altered whilst data stored in ROM can only be read;
RAM is used to store the data that has to be currently processed by CPU whilst ROM stores the instructions required during bootstrap of the computer;
RAM- large physical chip size/ higher capacity/expensive whilst ROM- small size/ less capacity/cheaper;
The CPU can access the data stored in RAM whilst the CPU cannot access the data stored on ROM (unless the data is stored in RAM);

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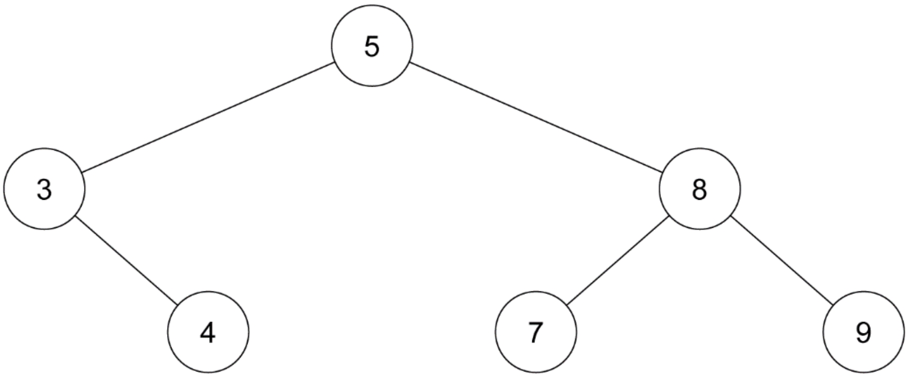
8. (a) *Award* ***[1 max]***

4 7 9;

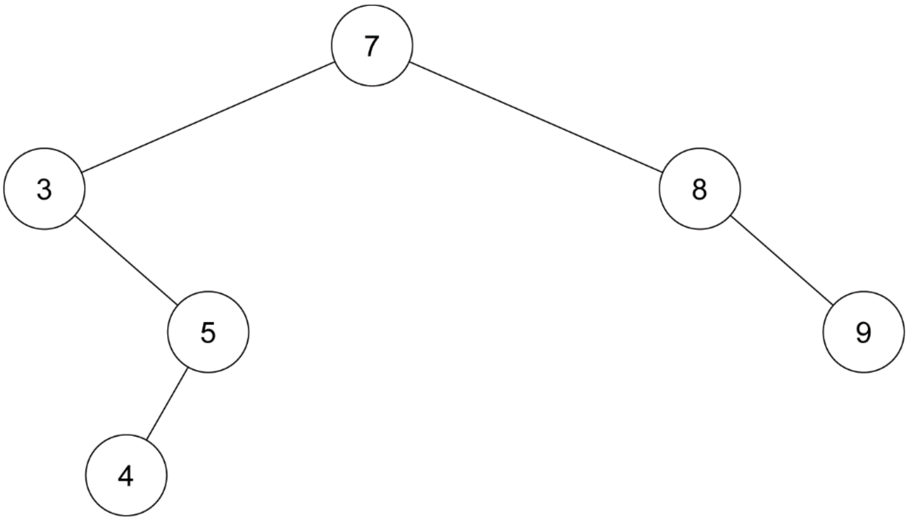
(b) *Award* ***[1 max]***

6 3 5 4 8 7 9;

(c) *Award [3* ***max****]*
Award ***[1]*** *for the correct root*
Award ***[1]*** *for the correct left subtree*
Award ***[1]*** *for the correct right sub-tree.*



OR



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9. *Award* ***[2 max]***

Award ***[1]*** *for stating a disadvantage and award* ***[1]*** *for an expansion.*

Performances drop;
Because of the time to switch among applications/ time taken to swap pages/blocks of data from secondary memory to RAM;

Processing time slows down/ more time required to complete the task;
As secondary storage devices have slower access times than RAM;

May require more secondary storage/ take up more space;
Because part of the disk is reserved for virtual memory, hence additional storage space might be necessary;

Increases power consumption;
Because of the increased overall processing time;

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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);

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(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).

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(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 can 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.*

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(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;

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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 (between 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;

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(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.*

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12. (a) *Award* ***[5 max]***

a pre-set value of temperature stored/ user inputs a desired temperature;
sensor measures/detects temperature;
and it (regularly) sends the temperature readings to the microprocessor;
microprocessor compares the actual readings with the pre-set/inputted temperature;
if the temperature is above or below the pre-set temperature/ too hot or too cold;
then the microprocessor sends signal to output transducer to adjust temperature accordingly;
These steps are (continuously) repeated in a cycle;

Note*: Award* ***[1 max]*** *for AD or/and DA conversion, if explained in the response.*

(b) *Award* ***[2 max]***
A feedback system samples the output signals (temperature) then a sample (a fraction of the output signal) is fed back to the input;
to change/modify the input signal;
in such a way as to produce an output signal that differs substantially from the output signal produced in the absence of such feedback / as to increase or decrease the temperature in the house;

The output value is (continuously) compared to the desired value to produce an error value/ difference/ adjusting factor;
the error value/ difference/ adjusting factor is fed to input;
to determine the next action/ to achieve a desired outcome/pre-set temperature in the room;

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(c) (i) *Award **[2 max]***
*Award **[1]** for identifying a function of an OS, and **[1]** for a description.*

*Award marks for **any** of the OS functions, for example, memory management, processor management, device management, coordination between other software and users, security, control over system performance, file management, etc.*

For example
Processor Management/Scheduling;
the OS decides the order in which processes have access to the processor / how much processing time each process has/ keeps tracks of the status of processes/ allocates the CPU to a process/ de-allocates processor when a process is no more required;

(ii) *Award **[2 max]***
Note: Accept reasons such as security, customisability, size, speed.
Because a dedicated operating system is custom made/ designed specifically for the computer system/ for the available hardware;
to do a specific function at maximum efficiency/ makes the most efficient use of the available resources;

Because the OS is specifically made to manage the control system/ for cell phone (that does not require to do any general-purpose tasks);
meaning that it is faster than universal OS;

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(d) *Award **[4 max]***
Award marks for giving an account of similarities and differences between centralized system and distributed system.

*Award **[2 max]** for centralized system.*
Easier to use- it allows control at a central point;
Controlled by a single processor;
Centralized system is easy to physically secure;
More cost-efficient for small systems (such as a house);
Large systems are usually more expensive to install due to the connectivity required between the various components;
Highly dependent on the network connectivity (the system can fail if the nodes lose connectivity as there is only one central node).
If it must be expanded (new equipment and processes added) downtime is usually required;
When the software program must be modified it requires downtime/ can have inadvertent effects on the existing control scheme;
When the central server is down, no other entity is there to send/receive responses/requests;
In case of a local failure (usually) the whole system stops working;

*Award **[2 max]** for distributed system.*
Not beneficial to build and operate small distributed systems because of the low cost/benefit ratio;
Controlled by a collection of independent processors;
Distributed system is usually easier to install due to fewer connection issues;
Easier to modify/upgrade without disturbing other processes;
Allows individual control of settings at each unit or room, so it is more flexible;
More complicated to control remotely;
Difficult to know which node failed/ which node responded;
In case of a local failure, all other processes continue to work;

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

The working may be differently represented. If only the final result (5) is shown, then award only one mark.

```
func(5)
= func(4) +  func(3)                                                          ;
= func(3) +  func(2) +  func(2) +  func(1) =   func(3)  + 2 * func(2) + 1      ;
= func(2) +  func(1) +  2 (func(1) +  func(0) )+ 1 =  func(2) +1 + 2+1       ;
= func(1) +  func(0) + 4  = 1  +0 +  4  =5                                    ;
```

(b) *Award **[4 max]***
*Award **[1]** for a disadvantage and **[1]** for the elaboration, **x2**.*

recursion is memory intensive;
because memory (call stack) is used to store all the intermediate arguments and return values/ could lead to stack overflow (if there is a large amount of data);

recursion can be slow;
if not implemented correctly/if too many recursive calls occur;

difficult to think of the logic of a recursive function/ complexity of the paradigm;
hard to construct/ analyse /understand the code;

(c) *Award **[2 max]***
isEmpty() returns a Boolean value True if the stack size is 0, else it returns False/ checks if stack is empty or not;
it is used/called in conditions in if/while statements/ it is called before an attempt is made to remove the value from the stack;
to prevent performing operations on an empty stack/ to prevent stack underflow error;

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(d) *Award* ***[5 max]***

Award ***[1]*** *for correct use of the stack and queue access methods (isEmpty(), push(), pop(), enqueue(), dequeue())*
Award ***[1]*** *for loop through the TOWNS stack*
Award ***[1]*** *for taking an element from the top of the TOWNS stack*
Award ***[1]*** *for enqueuing the value popped from the TOWNS stack to the TEMP queue*
Award ***[1]*** *for loop through the TEMP queue*
Award ***[1]*** *for pushing the value dequeued from the TEMP queue onto the TOWNS stack*

Example:

```
loop while not TOWNS.isEmpty()
    X=TOWNS.pop()
    TEMP.enqueue(X)  //TEMP is an empty queue
end while
loop while not TEMP.isEmpty()
    Y=TEMP.dequeue()     //instead of these 2 statements
    TOWNS.push(Y)        //TOWNS.push(TEMP.dequeue())
                          //can be written
end while
```

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

*Award **[1]** for a correct row loop*
*Award **[1]** for a correct column loop*
*Award **[1]** for initializing SUM and summing inside the loop using correct array indexes*

Example 1:

```
SUM=0
loop I from 0 to 6
       //accept DICEDIAL.length-1
       // or len(DICEDIAL)-1 instead of 6
   loop J from 0 to 2
        //accept DICEDIAL[I].length-1
       // or len(DICEDIAL[I])-1 instead of 2

      SUM = SUM + DICEDIAL[I][J]
   end loop
end loop
```

Example 2:

```
I =0
SUM=0
loop while I <= 6
      j=0
      loop while J <= 2
         SUM =SUM + DICEDIAL[I][J]
         J = J + 1
      end loop
      I = I + 1
end loop
```

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(b) *Award **[4 max]***

Example 1 (if-else statement):
*Award **[1]** for initializing VAL to 0 and return VAL / return 0 (in case no duplicates)*
*Award **[3 max]** for determining a correct value (1 mark for each correct condition and change of the value of VAL if needed)*

***Note**: Award marks for determining a correct return value in each of possible cases: three different values in row R- no duplicates, any two numbers/values in row R are the same and all three values in row R are the same.*
*Award **[1]** for correct use of row index and column index in the DICEDIAL array*

***Note**: the method heading may not appear in a candidate's response.*

```
DuplicateNum (DICEDIAL, R)
    VAL=0
    if DICEDIAL[R][0] = DICEDIAL[R][1]
        then
            VAL= DICEDIAL[R][0] // or VAL= DICEDIAL[R][1]
        else
           if DICEDIAL[R][0] = DICEDIAL[R][2]
               then VAL= DICEDIAL[R][0]
               else
                    if DICEDIAL[R][1] = DICEDIAL[R][2]
                          then VAL= DICEDIAL[R][1]
                     end if
             end if
     end if
return VAL
end DuplicateNum
```

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Example 2 (several if statements- inefficient, but it outputs a correct value):
*Award **[1]** for each correct if statement, **x4***
*Award **[1]** for correct use of row index and column index in the DICEDIAL array*

```
if //three different numbers
  DICEDIAL[R][0]!=DICEDIAL[R][1]
     and DICEDIAL[R][0]!=DICEDIAL[R][2]
         and DICEDIAL[R][1]!=DICEDIAL[R][2]
  then
      RESULT=0
end if
if DICEDIAL[R][0]=DICEDIAL[R][1] and DICEDIAL[R][0]=DICEDIAL[R][2]
  then //three same numbers
      RESULT = DICEDIAL[R][0]
end if
//any two same
if DICEDIAL[R][0]=DICEDIAL[R][1] or DICEDIAL[R][0]=DICEDIAL[R][2]
  then
      RESULT = DICEDIAL[R][0]
end if
if DICEDIAL[R][1]=DICEDIAL[R][2]
     then
          RESULT = DICEDIAL[R][1]
end if
return RESULT
```

***Note**: Accept answers written in Java/ Python. The following example answer is written in Java.*

```
public int DuplicateNum (int[][] DiceDial, int row)
{
if(DiceDial[row][0] == DiceDial[row][1]  || DiceDial[row][0] ==
DiceDial[row][2])
       {
       return DiceDial[row][0];
       }
    else if(DiceDial[row][1] == DiceDial[row][2])
                  {
                     return DiceDial[row][1];
                  }
                 else return 0;
}
```

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Example 3 (single loop):
*Award **[1]** for initializing VAL to 0 and return VAL*
*Award **[1]** for correct loop*
*Award **[1]** for correct condition and change of VAL*
*Award **[1]** for if statement after the loop*
*Award **[1]** for correct use of row index and column index in the DICEDIAL array*

```
DuplicateNum (DICEDIAL, R)
VAL=0
loop K from 0 to 1
    if (DICEDIAL[R][K]== DICEDIAL[R][K+1])
          then
             VAL= DICEDIAL[R][K]// or DICEDIAL[R][K+1]
    end if
end loop // determines VAL
         //comparing only DICEDIAL[R][0] with DICEDIAL[R][1]
         // and DICEDIAL[R][1] with DICEDIAL[R][2]
if (DICEDIAL[R][0] == DICEDIAL[R][2])
          then
             VAL= DICEDIAL[R][0] //or DICEDIAL[R][2]
end if
return VAL
end DuplicateNum
```

Example 4 (nested loops):
*Award **[1]** for initializing VAL to 0 and return VAL*
*Award **[1]** for correct outer loop*
*Award **[1]** for correct inner loop*
*Award **[1]** for correct condition and change of VAL*
*Award **[1]** for correct use of indexes in the DICEDIAL array*

```
VAL =0
 loop K from 0 to 1
   loop J from K + 1 to 2
       if DICEDIAL[R][K] == DICEDIAL[R][J]
          then VAL = DICEDIAL[R][K]
       end if
   end loop
end loop
return VAL
```

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

Example 1:
*Award **[1]** for initializing HIGHEST*
*Award **[1]** for correct row loop (I)*
*Award **[1]** for calculating the sum of all elements in the Ith row*
*Award **[1]** for using correct indexes in the DICEDIAL array*
*Award **[1]** for comparing the row sum with the highest row sum so far*
*Award **[1]** for and changing the value of HIGHEST if needed*
*Award **[1]** for outputting the highest row sum once*
*Award **[1]** for the second loop*
*Award **[1**] for comparing the row total with the highest row total*
*Award **[1]** for outputting row numbers (rows with the highest total)*

***Note**: The method heading may not appear in candidates' responses.*

```
highestRT(DICEDIAL)

   HIGHEST = 0  // any number <= 0 OR the first-row total
   loop I from 0 to 6
      SUM = DICEDIAL[I][0] + DICEDIAL[I][1] + DICEDIAL[I][2]
      //inner loop may be used instead of this statement
      //(see Example 2)- to calculate SUM of values in row I
      if SUM > HIGHEST // or >=
           then HIGHEST = SUM
       end if
    end loop
    output('the highest row total:', HIGHEST)
    output('the highest row total occurs in the following rows:')
    loop I from 0 to 6
      SUM = DICEDIAL[I][0] + DICEDIAL[I][1] + DICEDIAL[I][2]
      if SUM = HIGHEST
           then output (I)
       end if
     end loop
end highestRT
```

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Example 2:

Award ***[2 max]*** *for defining the ROWTOTALS array (1 mark for correct row loop (I) and 1 mark for calculating the sum of all elements in the I*th *row of the DICEDIAL array)*
Award ***[1]*** *for initializing HIGHEST*
Award ***[3 max]*** *for searching for the highest (1 mark for the correct loop, 1 mark for comparing the row sum with the highest row sum so far and 1 mark for and changing the value of HIGHEST if needed)*
Award ***[1]*** *for outputting the highest row sum once*
Award ***[3 max]*** *outputting the numbers of rows with the highest total (1 mark for a loop, 1 mark for comparing the row total with the highest total and 1 mark for outputting the corresponding index in the ROWTOTALS array)*

```
 loop I from 0 to 6
    S = 0
    loop K from 0 to 2
       S = S + DICEDIAL[I][K]
    end loop
    ROWTOTALS[I] = S
 end loop
       //ROWTOTALS[R] holds the sum of all
       //numbers in row R of the DICEDIAL array

HIGHEST = 0  //any number <= 0 OR ROWTOTALS[0]

 loop I from 0 to 6
  if ROWTOTALS[I] > HIGHEST
        then   HIGHEST = ROWTOTALS[I]
    end if
 end loop     //searching for the highest row total

output('the highest row total:', HIGHEST)

output('the highest row total occurs in the following rows:')

 loop I from 0 to 6
     if ROWTOTALS[I] = HIGHEST
        then output(I)
    end if
 end loop
```

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Example 3:

*Award **[1]** for initializing MAXT*

*Award **[1]** for correct row loop (R)*

*Award **[1]** for calculating the sum of all elements in row R (using correct indexes in the DICEDIAL array)*

*Award **[1]** for comparing the row sum with the highest row sum so far (S == MAXT), and changing the value FLAGMAXTIND[R] to 1 if they are equal*

*Award **[1]** for comparing the row sum with the highest row sum so far (S > MAXT) and updating the highest row sum so far*

*Award **[1]** for reinitializing FLAGMAXTIND array*

*Award **[1]** for changing the value FLAGMAXTIND[R] to 1*

*Award **[1]** for outputting the highest row total only once*

*Award **[2]** for outputting row numbers with the highest total (1 mark for a loop, 1 mark for output within if statement)*

```
// assume FLAGMAXTIND - zero array initialized
MAXT = 0
loop R from 0 to 6
      S = DICEDIAL[R][0]+ DICEDIAL[R][1]+ DICEDIAL[R][2]
      if S = MAXT
          then
                FLAGMAXTIND[R]=1
         end if
       if S > MAXT
           then
                MAXT = S
                loop K from 0 to 6
                     FLAGMAXTIND[K]=0
                end loop
                FLAGMAXTIND[R]=1
       end if
end loop

output('The highest row total is', MAXT)

output(' and it occurs in the following rows:')
loop R from 0 to 6
         if FLAGMAXTIND[R] == 1 // or FLAGMAXTIND[R] != 0
              then
                  output(R)
         end if
end loop
```

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