Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2024

Computer science

Higher level

Paper 1

International Baccalaureate
Baccalauréat International
Bachillerato Internacional

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. (a) *Award [1 max]*
Easily deployable and can be implemented on demand;
Cost effective - flexible payment methods such as pay - as- you -go models;
Can be accessed anywhere/anytime/from any device;
Reduction in costs as no need to host software installation/ less hardware / pay personnel/rental costs;
Scalability / can increase subscription or reduce it as required very quickly;
Software always / regularly up to date at the supplier's side without the need for installing patches / updates/upgrades;
Ensured compatibility/ easier collaboration - all users have the same version of the software;
Increased security;
Easier administration - less maintenance/less hardware required;
Technical support given by the provider;

(b) *Award [1 max]*
Confidentiality concerns if data related to customer is also stored on the supplier's hardware;
Stability issues / latency issues - dependence on good quality internet connection can mean if the internet is down/low quality connection, no work/ slow work;
If the service goes bankrupt/ shuts down you can lose your applications and data;
Critical business functions are left in the control of a third party/organization has no direct control of its own data;
If the quality of service provided by the supplier is not up to the standard, data loss or corruption can occur;
Limited customization;
Issues with interoperability and data exchange between different platforms due to incompatible/ limited API.
Security concerns as higher risk of failure/attack/interception;
Time delay in contacting/receiving response from the supplier/customer support if there is an issue/ different time zones;
Can turn out to be costly in the long run;

2. *Award [2 max]*
Award [1] for the purpose and award [1] for appropriate extension.

Examples :

User acceptance testing evaluates a product/software to make sure it is up to specifications/ user requirements/functions as intended;
before putting it into production/ before release;

It tests for the functionality of the product;
ensuring that bug fixes / modifications can be completed (in a more cost-effective manner);

It serves as a form of quality check;
to identify problems and defects through user feedback;

3.   *Award [1 max]*
A hardware/device that is <u>connected to/ attached to /external to/ auxiliary to the computer;</u>
A device used for input, output or storage that is <u>external/ attached to a computer;</u>

4.   *Award [2 max]*
Very small text and readability;
Very small functional elements / difficult to navigate;
Clutter on the screen;
Low contrast between text and functional elements / poor colour choices for visibility;
Size of screen (difficult to see in poor light);
Size of keys (difficult to access functions);
Battery life (may need to recharge frequently);
Touch screen keys (lack of tactile feedback);
Gesture (unresponsive gestures in user interfaces);
Too many clicks to complete tasks;
Limited storage/ RAM ;

***Note:** Reward other suitable issues*

5.   *Award [2 max]*
Use of touch screen;
Voice recognition;
Braille keyboards;
Text-to-speech/screen readers;
Hotkeys ;
Larger screens ;
Larger text options;
Size and sensitivity of touchpad - larger/ less sensitive touchpads ;

***Note:** Reward other suitable answers*

6.   *Award [2 max]*
To hold address of a location/data address/ instruction address/ address copied from the PC;
To be transferred/fetched to/from the main/primary storage of the computer OR to be read from/written to;

7   (a) *Award [1 max]*
    FB

    (b) A*ward [1 max]*
    01011001 OR 1011001

8.   *Award [2 max]*
Running recursive processes;
Holding return memory addresses / function call;
Expression evaluation and conversion/ evaluating arithmetic expressions;
String reversal;
Interrupt handling ;
Undo / redo in gaming/any other example;
Backwards navigation on Web browser;
Backtracking path in algorithms;
Stack based parsing algorithms;
Reversing a queue;
Depth first search algorithms;

9. *Award [2 max]*

Award [1] for technique and award [1] for description.

Scheduling;
Selecting a process (from a ready queue) and allocating CPU to this process for execution;

Time Slicing;
Allocating slices/ fractions of time to each process to enable programs to run simultaneously;

Multitasking;
Allowing a user to perform more than one computer task at a time;
to enable more than one application to run at the same time/ simultaneously;

Virtual memory;
A section of secondary storage set up to act as a primary storage;

Paging;
A memory management mechanism used to swap processes from secondary storage to primary storage as they are needed, (in the form of equal sized pages);

Interrupt;
A signal emitted by hardware or software to require the processor to stop its current process (if it is of lower priority) and action the task related to the interrupt;

Polling;
The constant checking the status of devices to see if they need the attention of the CPU;

Note : *Accept other appropriate description.*
No mark for description if the name of the technique is not correctly identified.

10. *Award [2 max]*
Award [1] for type of sensor and award *[1]* for appropriate extension.

Water level sensor/ ultrasonic sensor;
To switch water supply on/off as required / to make sure sufficient water is in the machine/keep door locked until water drains;

Proximity sensor;
To make sure the door is closed before starting the machine;

Vibration sensor;
To stop the drum from spinning if the load is unbalanced;

Speed (of rotation) sensor;
To make sure the drum is rotating at the correct speed of the wash cycle;

Load/ weight sensor;
to measure the weight of laundry and adjust the washing parameters;

Pressure sensor;
to monitor the water pressure and water levels inside the tub;

Moisture sensor;
to control auto-dry cycles/ how dry the clothes are;

Dirt sensor;
Detects soil and detergent levels and adjusts the washing cycle;

Note : *Sensor type <u>must </u>be identified to get a mark for extension.*

11. *Award [4 max]*

Input to the system is provided by sensors/ temperature sensor;
Sensors continuously send <u>digitised </u>data to microprocessor/ ADC converts data collected from sensors to digital data and sends it to the microprocessor;
The <u>microprocessor </u>would then compare the input readings against stored values / required temperature settings;
The microprocessor would then calculate any error value/adjusting factor required for the heating / cooling equipment;
This difference /error value is fed back to the microprocessor to perform a suitable action (by heater/cooler)/ Error value is fed back as an input to the system;
The above steps are repeated until the system is turned off which maintains the temperature of a room;

Section B

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

Allows very fast transmission of data/ extremely high bandwidth possible;
(Made of glass/plastic fibre) that can transfer information via pulses of light;
Immune to electromagnetic interference/temperature changes/ severe weather/highly resistant to noise and moisture;
Very high security rating;
Safe to use in high-voltage locations, areas where flammable gases/ chemicals;
Very long distance of transmission before requiring repeaters/ attenuation;
They have a long lifespan (thinner and light weighted, so more flexible than other media);
Expensive/ harder to install;

(ii) *Award [2 max]*

Uses radio waves/ electromagnetic waves to transfer data;
Transmission speed of data is limited;
Range of transmission /transmission reliability can be affected by distance from access point/number of other users/ obstacles etc;
Inexpensive to install/ no need to spend on cabling;
Relatively easy to expand/ add new devices/ scale down to accommodate changes in demand;
Security can be poor (unless encryption is applied) / subject to eavesdropping/interception;
Allows users to move around without losing access to the network;

(b) *Award [3 max]*

Plain text is changed to cypher text/ data is scrambled using an <u>encryption algorithm/ key</u> /<u>A key</u> is required by sender and receiver for authentication;
Cypher text/data cannot be understood if intercepted;
The cypher text/data is then decrypted using a (decryption) <u>key</u> when received by the receiver;

(c) *Award [5 max]*

The whole data is split into (fixed/equal) sized chunks/packets;
Each packet has a header, payload and trailer;
Packet contains information such as source, destination IP addresses, packet number, protocol, checksum, payload/data, CRC etc (at least two);
Each packet is sent individually/independently along the best path (by a router);
Packets may take different routes to the destination;
If a route becomes unavailable, individual packets can be re-routed;
Packets (may) arrive at the destination out of order;
Packets are re-ordered/joined together at the destination;
Missing packets can be re-sent;

(d) *Award [3 max]*
Award [1] for implication (positive or negative) and award [2] for further expansion.

Example 1:
Improved work/life balance ;
Working from home / access to work materials has become much easier / more secure which can allow more time to be spent at home;
Time spent on travelling to work can now be spent with the family / on hobbies and interests/ travelling;
Also, working hours can be flexible, so the employee is less likely to feel stressed leading to improved mental health;

Example 2:
It can have a negative impact on work/life balance;
With working from home some workers may feel that their employer has higher expectations of the amount of work they should be doing because of the time they have saved not having to travel to work;
Also, some workers may feel that their employer doesn't trust that they are fully committed to working when at home/ distracted by family, so feel under pressure to spend more time on the job/cannot concentrate enough on job, leading to poorer mental health;

Example 3:
Working from home may also result in less collaboration/team work.
As working at different times/ zones may not allow employees to communicate effectively with each other;
and feeling of isolation can affect mental health and productivity;

Note : *No marks if there is no social implication mentioned.*

13. (a) *Award [1 max]*
Award [1] for *either the description OR the truth table.*

Outputs the value of one if and only if all inputs have a value of zero;

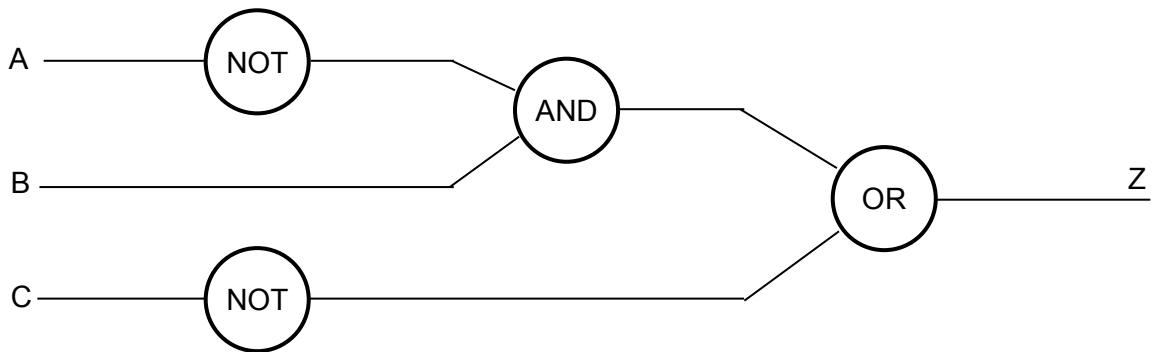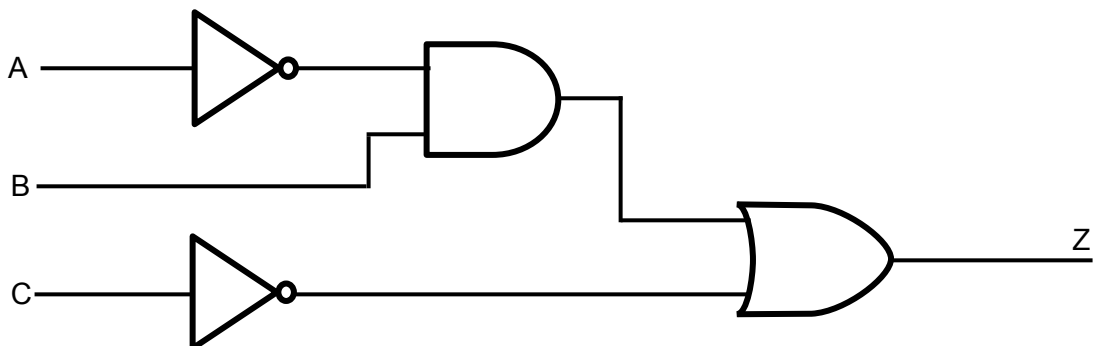| A	B	Z
0	0	1
0	1	0
1	0	0
1	1	0

Note : *DO NOT accept –reverse/ negates OR*

(b) *Award [4 max]*
Correct NOT gate with input A and single output;
Correct NOT gate with input C and single output ;
Correct AND gate with two inputs - one input from B and one output;
Correct OR gate with two inputs and one output Z;

Answer should represent Z = A'.B + C'
Example answer

Alternative answer

(c) *Award [2 max]*
Award *[1]* for each correct row (The rules for 0 and 1 can be reversed).

D	0	Obstruction is less than 3 metres from the rear of the car/ There are obstructions less than 3 metres from the rear of the car
	1	Obstruction is 3 or more metres from the rear of the car /There are no obstructions less than 3 metres from the rear of the car

(d) *Award [2 max]*
Award [1] for evidence of working e.g. substitution into variables to evaluate the expression;
Award [1] for correct answer `true`;

Example answer
```
40 >= 25 AND 115 >= 5 AND 115 <= 130 AND true
true AND true AND true AND true
(Output =) true
```

Note : *Accept 1/0 instead of true/false*

(e) *Award [6 max]*
Use of flag (or otherwise) to maintain <u>continuous</u> loop;
Appropriate loop structure – while / repeat..until;
Inputs for distance and speed inside the loop;
Correct condition to implement alarm notification;
Correct output of alarm;
Correct condition to cause loop to stop;

Note : *Do not accept break to terminate the loop*

Example answer 1
```
FLAG = true
loop while FLAG
  input D // allow read D
  input S // allow read S
  if D < 15 OR S > 115 then
    output "ALARM!!"// allow any other output
  end if
  if S = 0 then
    FLAG = false
  end if
end loop
```

Award [6 max]
Input of speed before the loop;
Appropriate loop structure – while/repeat until;
Inputs for distance and speed - after the endif. Both inputs inside the loop;
Correct condition to implement alarm notification;
Correct output of alarm;
Correct condition to cause loop to stop;

Note : *Do not accept break to terminate the loop*

Example answer 2
```
input S
loop while S > 0
  input D // allow read D
  if D < 15 OR S > 115 then
    output "ALARM!!" // allow any other output
  end if
  input S // allow read S
 end loop
```

14. (a) *Award [2 max]*
Malicious activities/hacking/ malware/viruses/worms;
Natural disasters;
Accidental loss/human error;
Hardware/power breakdown;
Data transmission errors;
Poor backup strategies;
Software failure;

(b) *Award [2 max]*
Award [1] for consequence to the hotel and award [1] for further expansion on the same consequence.

Customers may arrive at the hotel when the hotel doesn't expect them/ overbooking;
Causing loss of business/bad reputation/money for the hotel;

Hotel is unable to plan;
As it doesn't know how many reservations have been lost;

Hotel cannot contact customers to confirm bookings;
Because customer details were lost with the reservations data;

Note : *Accept any answer which highlights difficulty faced by the hotel with a further expansion.*

(c)   *Award [2 max]*
Award [1] for the method and award [1] for further expansion on the same method.

Regularly backup data by making a file of current transactions;
and storing another copy of the data in another location / in a secure location / in a fireproof safe;

Use a failover system / redundant system;
So that if anything happens to the main system, the alternative system may be implemented immediately;

Use offsite/online/cloud storage for the data;
Data is not lost if the hotel hardware is unavailable or damaged / data can still be accessed by an alternative system;

Use firewalls/ anti-malware/ anti-virus etc ;
to prevent malicious activities, other threats and errors during transmission;

Provide training to the employees;
to avoid accidental deletion or human errors;

(d)   *Award [2 max]*
Award *[1]* for the problem and award *[1]* for a suitable extension.

Data not being stored / not transferred correctly /data loss/data corruption;
due to incompatible software/ hardware/ file formats / data structures / database formats/ Validation rules/data integrity issues/power failure;

Data inconsistencies/incompatibility;
due to incompatible conventions of dates / currencies / time/ character sets;

Potential security risks;
due to breach of sensitive information, data leakage and unauthorised access during data transfer ;

(e)   *Award [3 max]*
      At least 1 difference and 1 similarity.

Primary and secondary storage in a tablet have a lower capacity as compared to desktop computers;

Primary and secondary storage in a tablet is smaller in physical size and hence more compact as compared to those in a desktop computer to allow for portability;

Secondary storage on a tablet is usually a single hard-disk drive/solid-state device. A desktop computer may have multiple secondary storage devices of the same or different type;

The memory resources on a tablet computer usually remain as they were when purchased, but may have limited upgrade capabilities. A desktop computer's primary and secondary memory can be upgraded with ease to improve the performance/storage capabilities of the computer;

In both tablets and desktop computers the secondary memory has a slower access time compared to primary memory as they cannot be directly accessed by the CPU;

In both types of devices primary memory can be volatile, while secondary memory is only non-volatile;

Note : *Reward other suitable answers*

(f)   (i) *Award [1 max]*
         Processor /graphics processor;
         Cache;
         Screen (size/resolution);
         Network card (NIC) ;
         USB port;
         Sound processor;

         Note : *Reward other possible resources <u>within</u> the tablet and desktop computers*

      (ii) *Award [3 max]*
         Desktop computers can access a network using a wired / ethernet connection;
         Tablet computers uses a wireless connection to connect to the network;
         Desktop computers can connect the network at higher data transfer speeds due to their ability to use wired connections;
         Desktop computers don't generally have mobile connectivity, unless it is added as part of a network card;
         Tablet computers are more flexible in terms of where they can access a network due to their portability;
         Tablet computers network connectivity is more prone to be effected by obstacles/ distance from the access point / number of other users;

15. (a)   (i) *Award [2 max]*
      Award [1] for the benefit and award [1] for expansion.

      Efficient use of memory;
      memory is allocated during the execution of the program as needed / memory is deallocated and re-used when no longer required;

      There is no need to predefine the size of a dynamic data structure;
      so, they can grow/data can be added or shrink in size/data removed depending on the requirements;

      Efficient insertion and deletion operations can be carried out;
      with the adjustment of pointers/ no need to shift elements / as they are stored in chained memory locations;

  (ii) *Award [2 max]*
      Award [1] for drawback and award [1] for further expansion.

      (Memory) overflow;
      Can happen if more memory is actually used than has been allocated/available;

      (Memory) underflow;
      can happen if attempting to delete an element from an empty data structure;

      Harder to program;
      because it is more difficult to keep track of the size and location of the data structure;

      Potential for memory leaks;
      when allocated memory is not properly deallocated after use;

      Errors, crashes & security vulnerabilities;
      due to null pointer dereferencing, dangling pointers, or memory access violations;

      More memory usage for the set amount of data;
      as dynamic data structures require additional memory to store pointers;

      Slower execution time/longer to traverse etc;
      due to more programming statements required/ manipulation of pointers;

(b) *Award [5 max]*
Initialise pointer to head/start of linked list;
check if data item is desired value/21;
if not, store the value of pointer in previous pointer ;
and then change the pointer to next position in linked list;
repeat until data item 21 is found (or until end of list reached);
if data item 21 found, change the next (pointer) of the previous pointer to point to the following node / node containing 30;
clear the memory for the deleted node / node containing 21;

Alternate answer:
Check the data item at head to see if it is the desired value/21;
if not, initialise a current pointer to point to next node in the linked list;
check the next item in the linked list;
repeat until data item 21 is found (or until end of list reached);
if data item 21 found, change the next of the current pointer to point to node after the next node (current.next = current.next.next)/ node containing 30;
clear the memory for the deleted node/ node containing 21

(c) *Award [2 max]*
A node contains a data element;
A node has two pointers (a pointer to a left child (node) and a pointer to the right child (node))

(d) (i) *Award [3 max]*
Root node correct;
Left subtree correct;
Right subtree correct;
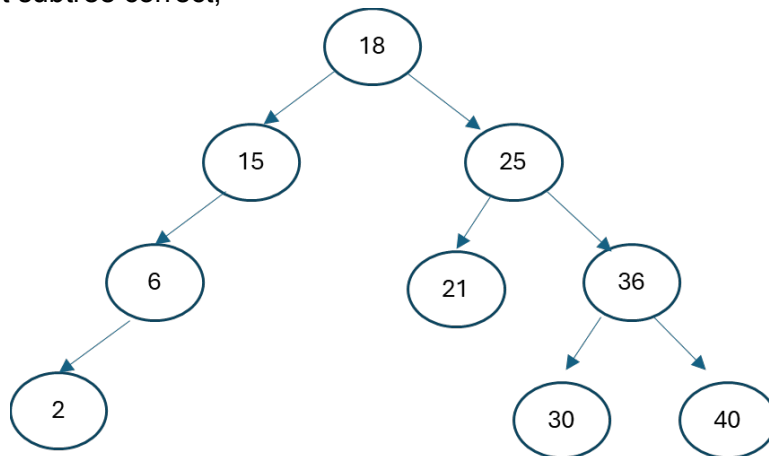
(d) (ii) *Award [1 max]*
2, 21, 30,40

*Candidate's answer **must** match their answer to part (d)(i).*
Allow follow through from part (d)(i).

16   (a)   *Award [2 max]*
           Award [1] for each correction (shown in bold)

```
input X
loop while (lenString(X) < 10) OR (lenString(X) > 25)
    output "The string's length is out of range, please try again"
    input X
end loop
```

     (b)   *Award [5 max]*
           Correct J columns;
           Correct C and X columns;
           Correct Y and Z columns;
           Correct R column;
           Correct S column;

           Alternate Mark Scheme (row-wise)
           Award *[4]* for the first 4 rows;
           Award *[1]* for the last row <u>and</u> terminating when C is 4;

J	C	X	Y	Z	R	S
	1	ADONUS	3	2	NU	UN
UN	2	FERGUS	0	3	FER	REF
REFUN	3	NASREEN	1	4	ASRE	ERSA
ERSAREFUN	4	TUPPENCE	0	3	TUP	PUT
PUTERSAREFUN						

16 (c) *Award [8 max]*
Award [2] for correct use of string manipulation functions:
Checking the length of the password is >=8 using `lenString` correctly;
Correct use of `subString` to check for recurring adjacent characters;

Award [6]:
Correct first input of password;
Use of flag or other method to prevent further checks, if length check fails;
Use of loop to check for recurring adjacent characters;
Use of flag or other method to prevent final checks if recurring characters check fails;
Correct repeat input for password;
Correct check that both password entries match;
Appropriate output to user throughout to reject and/or accept password;
Correct method to re-enter incorrect password;

Example answer 1 (based on `subString`)
```
FAIL = true
loop while FAIL = true  // loop while FAIL
   FAIL = false
    output " Please enter a password that is at least 8 characters
        long with no consecutive repeated characters "
    input PW
    if lenString(PW)<8 then
        output "Password is too short, try again"
        FAIL = true
    end if
   if FAIL = false then // if NOT FAIL then
      POS = 0
       loop while POS < lenString(PW) - 1
         if subString(PW, POS, 1) = subString(PW, POS + 1, 1) then
                                      //Accept .equals and ==
            FAIL = true
            POS = lenString(PW) – 1
            output "Password has repeated characters, try again "
          end if
         POS = POS + 1
       end loop
   end if
   if FAIL = false then // if NOT FAIL then
      output "Please re-enter your password "
      input PW2
      if PW ≠ PW2 then
        output "Your password re-entry does not match, try again "
        FAIL = true
      else
        output "Your password is accepted "
      end if
   end if
end loop
```

Award [8 max]
Award [2] for use of string manipulation functions
Checking the length of the password is >=8 using `lenString`;
Correct use of `subString` and `revString` to check for recurring adjacent characters;

Award [6]:
Correct first input of password;
Use of flag or other method to prevent further checks, if length check fails;
Use of loop to check for recurring adjacent characters;
Use of flag or other method to prevent final checks if recurring characters check fails;
Correct repeat input for password;
Correct check that both password entries match;
Appropriate output to user throughout to reject and/or accept password;
Correct method to re-enter incorrect password;

Example answer 2 (based on `subString` and `revString`)

```
FAIL = true
loop while FAIL
  FAIL = false
  PW = input ("Enter a new password")
  if lenString(PW)<8 then
     output ("Password is too short")
     FAIL = true
  end if
  if not FAIL then
     loop POS from 0 to lenString(PW) – 2
        TEMP = subString(PW, POS, 2)
        if TEMP.equals(revString(TEMP)) then // Accept = or ==
           FAIL = true
        end if
     end loop
  if FAIL then
     output ("Repeated characters in password")
  end if
  if NOT FAIL then
     PWC= input ("Confirm password")
     if NOT (PW.equals(PWC)) then // Accept = or  ==
       output ("passwords do not match")
       FAIL = true
     else
       output("Your password is accepted")
     end if
  end if
end while
```