Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2023

Marking Scheme

Computer Science

Higher Level

Note to teachers and students on the use of published marking schemes

Marking schemes published by the State Examinations Commission are not intended to be standalone documents. They are an essential resource for examiners who receive training in the correct interpretation and application of the scheme. This training involves, among other things, marking samples of student work and discussing the marks awarded, so as to clarify the correct application of the scheme. The work of examiners is subsequently monitored by Advising Examiners to ensure consistent and accurate application of the marking scheme. This process is overseen by the Chief Examiner, usually assisted by a Chief Advising Examiner. The Chief Examiner is the final authority regarding whether or not the marking scheme has been correctly applied to any piece of candidate work.

Marking schemes are working documents. While a draft marking scheme is prepared in advance of the examination, the scheme is not finalised until examiners have applied it to candidates' work and the feedback from all examiners has been collated and considered in light of the full range of responses of candidates, the overall level of difficulty of the examination and the need to maintain consistency in standards from year to year. This published document contains the finalised scheme, as it was applied to all candidates' work.

In the case of marking schemes that include model solutions or answers, it should be noted that these are not intended to be exhaustive. Variations and alternatives may also be acceptable. Examiners must consider all answers on their merits, and will have consulted with their Advising Examiners when in doubt.

Future Marking Schemes

Assumptions about future marking schemes on the basis of past schemes should be avoided. While the underlying assessment principles remain the same, the details of the marking of a particular type of question may change in the context of the contribution of that question to the overall examination in a given year. The Chief Examiner in any given year has the responsibility to determine how best to ensure the fair and accurate assessment of candidates' work and to ensure consistency in the standard of the assessment from year to year. Accordingly, aspects of the structure, detail and application of the marking scheme for a particular examination are subject to change from one year to the next without notice.

Marking Scheme – Section C

Structure of the marking scheme for Section C (Programming)

Candidate responses are marked according to different scales, depending on the types of response anticipated. For example, scales labelled B divide candidate responses into four categories (correct response, almost correct response, partially correct response, and response of no substantial merit), and so on. The scales and the marks that they generate are summarised in this table:

Scale Label	A	B	C
No. of categories	2	4	5
5 mark scale	0, 5	0, 2, 3, 5	
10 mark scale		0, 3, 7, 10	0, 3, 5, 7, 10

A general descriptor of each point on each scale is given below. More specific directions in relation to interpreting the scales in the context of each question are given in the scheme, where necessary.

Marking scales – level descriptors

A-scales (2 categories)

- response of no substantial merit
- correct response

B-scales (4 categories)

- response of no substantial merit
- response with some merit
- almost correct response
- correct response

C-scales (5 categories)

- response of no substantial merit
- response with some merit
- response about half-right
- almost correct response
- correct response

Section A — Short Answer Questions — 54 marks

Answer any nine questions.

Question 1 **6 marks**

Value	Data Type
Ciara	**String/str**
255	**int/integer**
083-1234567	**String/str**
1.5, 1.7, 1.2, 0.9, 1.3	**List/array**
False	**Boolean/Bool**
-99.99	**Float/real**

Each correct response 1 mark

Question 2 **3 + 3 marks**

(a)

- **Hexadecimal is very concise. This means that it can be used to express most numbers using fewer digits/characters than would be needed in other number systems.**
- **Every hexadecimal digit/character can be represented using a group of four binary digits. This grouping makes it relatively easy and fast to convert between hexadecimal numbers and binary. It is also one of the reasons why hexadecimal numbers are considered more human-friendly than other number systems.**
- **Because of their conciseness, humans are less likely to make mistakes when writing hexadecimal numbers.**
- **Hexadecimal notation is commonly used as a convenient way to represent memory addresses, machine code/instructions, data, error codes, colours etc.**

Very good description - clear understanding demonstrated 3 marks
Fair description - limited understanding 2 marks

(b)

- **$Cx16^1 + 9x16^0 = 12x16 + 9x1 = 192+9 = 201$**

OR

- **STEP 1. Convert to binary: C9 = 1100 1001**
- **STEP 2. Convert to decimal:1100 1001 = 128 + 64+ 8 + 1 = 201**

Correct 3 marks
Calculation Error 2 marks
Response with some merit e.g. C=12 1 mark

Question 3 **3 + 3 marks**

(a)

x > 0	y > 0	x > 0 and y > 0
False	False	False
False	True	**False**
True	False	**False**
True	True	**True**

Each correct response 1 mark

(b)

(x > -d and x < 0) and (y >0 and y < d)
Note: brackets not necessary and order not important in this case.

Correct	3 marks
Half correct	2 marks
Response with some merit	1 mark

Question 4 **3+3(1,2) marks**

(a)

A user interface is the means by which the user provides input to a computer and the computer conveys output to the user. Specifically, it is the point of interaction between a user and a computer through the use of i/o devices.

Very good description - clear understanding demonstrated	3 marks
Fair description - limited understanding	2 marks

(b)

- **Graphical user interface (GUI) - an environment with windows, icons, menus and controlled by a pointing device (WIMP). This type of interface is called the graphical user interface (GUI) because the user interacts with images through a mouse, keyboard or touchscreen. Used on most computers & smartphones.**
- **Command line interface (CLI) - provides a method of interaction that is non-graphical, called the command line interface (CLI). This is a text-only service with feedback from the OS appearing in text. Using a CLI requires knowledge of the commands available on a particular machine.**
- **Menu driven interfaces - user can select from a number of options, then typically only move up, down, back & forward. Often used in menus for food, tickets etc.**
- **Touch user interface - this is a type of interaction between a user and a computer-based device. This interaction is by doing a physical touch on the screen and the computer responds to this touch interaction.**

- **Natural Language interface (NLI) / Voice user interfaces (VUI) - these allow the user to interact with a system through voice or speech commands. Virtual assistants, such as Siri, Google Assistant, and Alexa, are examples of these type of interfaces.**
- **Any other acceptable response such as virtual reality (VR)/augmented reality (AR) and form based interfaces.**

Name:

Type of user interface correctly named	1 mark

Description:

Very good description - clear understanding demonstrated	2 marks
Fair description - limited understanding	1 mark

Question 5 **2 + 4 marks**

- **Application layer - encodes/decodes the message into a form that is understood by the sender and the recipient devices using protocols like HTTP, FTP and SMTP.**
- **Transport layer - breaks down the message into small pieces called packets. Each packet is given a packet number and the total number of packets. The recipient uses this information to assemble the packets in the correct order. It also allows the recipient to see if there are any missing packets.**
- **Network layer (aka internet layer) - adds the sender's IP address and that of the recipient. The network then knows where to send the message, and where it came from.**
- **Data link layer - enables the physical transfer of packets between nodes on a network, and between one network and another.**

Note: Some candidates may refer to the older OSI model which contains 7 layers in total (application, presentation, session, transport, network, data link and physical layers). These would also be acceptable.

Name of layer:

TCP/IP layer correctly named	2 marks

Description:

Very good description - clear understanding demonstrated	4 marks
Fair description - limited understanding/lacking demonstration of full understanding	2 marks

Question 6 **2+4(2,2) marks**

(a)

- **Programmable appliances e.g. washing machine, dishwasher, dryers, kettle, fridge**
- **Heating, ventilation and air conditioning system.**
- **Lighting control system.**
- **Alarm/security systems.**
- **Home robots e.g. Roomba, companion robots, window cleaners, lawnmowers**
- **Leak detection, smoke and carbon monoxide detectors.**
- **Home safety for the elderly and disabled.**
- **Pet and baby care.**
- **Voice control devices like Amazon Alexa or Google Home used to control home appliances or systems.**
- **Any acceptable smart home embedded system.**

Note: Do not accept Micro:bit, Raspberry Pi as valid examples.

Each correct example 1 mark

(b)

- **Embedded systems perform some specific function or tasks. Unlike computer systems they cannot be programmed to do anything beyond the scope which they were designed for.**
- **Low Cost – the price of embedded systems is relatively inexpensive.**
- **Time Specific –embedded systems perform tasks within a certain time frame (in real time).**
- **Low Power – embedded systems typically don't require much power to operate.**
- **Minimal User interface – embedded systems require less user interface that are easy to use.**
- **Less Human intervention – embedded systems require little or no human intervention.**
- **Highly Stable – embedded systems do not usually change frequently meaning they are easier to maintain.**
- **High Reliability –reliable is a key characteristic of embedded systems. They are required to perform their tasks consistently well.**
- **Use microprocessors or micro controllers – embedded systems use microprocessors or micro controllers to design and use limited memory.**

For each correctly identified characteristic:

Clear distinction between embedded systems and general computer systems 2 marks

Limited distinction between embedded systems and general computer systems 1 mark

Question 7 **6 marks**

x	y
10	5
9	**6**
8	**7**
7	**8**

Each correct response1 mark

Question 8 **1+4(2,2)+1 marks**

(a)

- **(W, W, W, W)**

Correct response 1 mark

(b)

(i)

- **(E, E, W, W)**
- **(E, W, W, E)**
- **(E, W, W, W)**
- **(W, E, E, E)**
- **(W, W, E, E)**
- **(W, E, E, W) – No marks awarded for this response as it is given as part of the question.**

Each correct response 2 marks

(ii)

- **(E, E, E, W)**
- **(E, E, W, E)**
- **(E, W, E, E)**
- **(E, W, E, W)**
- **(W, E, W, E)**
- **(W, E, W, W)**
- **(W, W, E, W)**
- **(W, W, W, E)**

Any correct response 1 mark

Question 9 **4+2 marks**

(a)

Cups (before move)	Move	Ball Position (after move)
['Ball', 0, 0]	**A**	**2**
[0, 'Ball', 0]	**B**	**2**
[0, 'Ball', 0]	**C**	**3**
[0, 0, 'Ball']	**B**	**1**
['Ball', 0, 0]	**C**	**1**
['Ball', 0, 0]	**A**	**2**

- **Answer: The ball position after ABCBCA is 2 (i.e. under the middle cup).**

Correct	4 marks
Half correct	2 marks
Response with some merit	1 mark

(b)

- **The complete list of 4 move sequences that work is: ['AAAA', 'AABB', 'AACC', 'ABAC', 'ABBA', 'ABCB', 'ACAB', 'ACBC', 'ACCA', 'BAAB', 'BABC', 'BACA', 'BBAA', 'BBBB', 'BBCC', 'BCAC', 'BCBA', 'BCCB', 'CAAC', 'CABA', 'CACB', 'CBAB', 'CBBC', 'CBCA', 'CCAA', 'CCBB', 'CCCC']**
- **Any 'same move' completed an even number of times (>= 4) e.g. AAAA, BBBBBB**
- **Any palindromic sequence of moves e.g. ABBA, ABCCBA**
- **Any other correct response**

Note: Odd length sequences will not work

Correct response	2 marks

Question 10

6(3,3) marks

(a)

30	**40**	**10**	**50**	**20**	**60**	**80**	**70**	**90**

OR

50	**30**	**20**	**40**	**10**	**60**	**80**	**70**	**90**

Elements split about the pivot	1 mark
Left sub-list correct	1 mark
Right sub-list correct	1 mark

(b)

- **Because 90 is the largest number in the list.**
- **Because it would increase the time taken to execute the algorithm.**

Very good description - clear understanding demonstrated	3 marks
Fair description - limited understanding	2 marks

Question 11 **2(1,1) + 4(2,2) marks**

(a)

- **Valid inputs: first_name, surname, date_of_birth.**
- **Valid output: username.**

Note: No marks awarded for actual names, dates or usernames (even if in correct format e.g. Joe Soap 26112003 and JoSoap2003)

Each correct response (1 input and 1 output)	1 mark

(b)

- **String slicing:**
  - **Step 5 of the algorithm slices the first two characters of the first_name.**
  - **Step 6 of the algorithm slices characters from positon 4 to 7 inclusive. Assuming ddmmyyyy format, this extracts the 4-digit year of birth from the date of birth.**
- **String concatenation:**
  - **Step 7 of the algorithm concatenates the 2 characters from the first name followed by the surname followed by the 4 digit year of birth to determine the username.**

For each explanation:

Very good explanation - clear understanding demonstrated	2 marks
Fair explanation - limited understanding	1 mark

Question 12 **2(1,1) + 4 marks**

(a)

The SDLC is important because it:

- **provides a structured approach (thereby helping to reduce complexity**
- **improves software quality (by increasing potential that project will meet user requirements and expectations while reducing risk of failure/errors.**
- **minimises overrun on budgets/cost.**
- **minimises the risk of missing project deadline(s).**
- **maximises use of resources / staff planning.**
- **encourages communication and collaboration among all project stakeholders**
- **Any other reasonable reason provided.**

Note: Where two separate responses are considered equivalent/to have the same meaning, marks are awarded for the best response only. Zero is awarded for the other response.

Each correct response	1 mark

(b)

- **Functional testing tests whether the system meets its requirements whereas non-functional testing tests how well those requirements are met e.g. performance, usability, reliability, scalability and other non-functional aspects of the software system**
- **Functional testing should be carried out before non-functional testing.**
- **Examples of functional testing include unit testing, smoke testing, integration testing, white box testing, black box testing, user acceptance testing and regression testing.**
- **Examples of non-functional testing include performance testing, stress testing, installation testing, usability testing, security testing, penetration testing and compatibility testing.**

Very good distinction - clear understanding demonstrated	4 marks
Fair distinction - limited understanding/lacking demonstration of full understanding	2 marks

Section B	Long Questions	76 marks

Question 13 **38 (19, 7, 12) marks**

(a) **19 (8,3,8) marks**

(i) **8(4, 4) marks**

Support

- **Local community and businesses can avail of dependable IT facilities/online services.**
- **Residents who once had to work in major towns/ cities can now work from their local area (remote working) instead of having to leave to find work elsewhere.**
- **Facilities might attract new people to live in the area.**
- **Boost to local economy.**
- **Accept any other reasonable positive argument.**

Against

- **House prices could increase due to high earners.**
- **Possible negative impact local culture, community and way of life.**
- **Increase population could drain infrastructure and resources in place.**
- **New businesses coming to the area could impact other businesses.**
- **Accept any other reasonable negative argument.**

For each of support and against:

Very good description - clear understanding demonstrated	4 marks
Fair description - limited understanding	2 marks

(ii) **3(1,2) marks**

- **Population –this could be used to determine whether it is viable to open a new hub. When combined with school population and capacity, hospital capacity etc., population models could also be used to determine whether there are enough resources to meet the potential additional demand on these services.**
- **Housing figures – could be used to model whether there would be enough accommodation for a potential increase in population.**
- **Broadband availability and broadband speed could be used to model whether the existing broadband infrastructure would be sufficient to meet potential extra demands.**
- **Any data item with a valid justification e.g. hub occupancy rates.**

Valid data item	1 mark
Justification:	
Very good justification - clear understanding demonstrated	2 marks
Fair justification - limited understanding	1 mark

(iii) **8(4,4) marks**

- **Braille keyboard - allows the user to type and enter text or instructions for the computer in Braille**
- **Screen reader - software that enables people with severe visual impairments to use a computer**
- **Screen magnifier - software that provides enlarged screen content for visual impairments**
- **Sip-and-puff - device that allows users to enter commands into a computer system via mouth**
- **Accept any other relevant examples and explanations such as,**
    - **Large monitors.**
    - **Alternative types of keyboard and mouse (e.g. on-screen keyboards, keyboard with modifications, etc.).**
    - **Accessibility tools built into popular OS, browsers, and application software (e.g. software to adjust screen colours, font characteristics, magnification applications, keyboard filters, etc.).**
    - **Computers with voice output.**
    - **Word prediction software.**
    - **Adapted pointing/input devices (e.g. gesture devices, eyeball tracking devices, chin pointing devices etc.).**
    - **Wands and sticks.**
    - **Joysticks.**
    - **Trackballs.**
    - **Touch screens.**

For each correctly identified type of technology	1 mark
For each technology:	
Very good description - clear understanding demonstrated	3 marks
Fair description – limited understanding	2 marks

(b) **7 (2, 2, 3) marks**

(i) **2 marks**

85 km

Hub A → Hub C → Hub B → Hub D → Hub A (15+25+30+15 = 85)

Hub A → Hub D → Hub B → Hub C → Hub A (15+30+25+15 = 85)

Correct response	2 mark
Response with some merit	1 mark

(ii)

2(1,1) marks

- **Circles and letters are used to represent hubs.**
- **Lines are used to represent roads.**
- **Numbers are used to represent distance.**
- **Scale is ignored.**
- **Geographic features such as lakes/rivers, hills/valleys, trees, houses etc. are all ignored.**
- **Any valid feature.**

For each feature:

Good description - clear understanding demonstrated 1 mark

(iii) **3 marks**

Heuristics

- **A heuristic is a problem-solving technique used to find the best approximate solution when other methods e.g. brute force, would take too long to calculate the optimal solution. An example of a heuristics is a guess which can be based on previous experience or rule of thumb. In this example, a good rule of thumb would be to always choose the next nearest city (hub).**

Very good explanation - clear understanding demonstrated 3 marks

Fair explanation - limited understanding 2 marks

(c) **12 (3, 3, 3, 3) marks**

For

- **Video surveillance is already being used. FSR technology would reduce the amount of time needed to manually look through video footage.**
- **Helps to rapidly identify criminals.**
- **Higher number of convictions.**
- **Reduced crime.**
- **Control measures can be put in place to safeguard against any ethical issues e.g. Codes of Practice to safeguard against misuse, GDPR can protect privacy.**
- **Accept any other reasonable positive argument.**

Against

- **Privacy (data protection risks – questions such as the following arise:**
  - **Who owns the data?**
  - **Can the data be retained and, if so, for how long?**
  - **What can the data be used for?**

- **Potential errors leading to mistaken identities.**
- **Bias. For example, if system is trained using datasets with predominately white males it may be less accurate on other demographics. This in turn could potentially lead to racism (and, in other types of systems, discrimination).**
- **Accept any other reasonable negative argument.**

Note: Where two separate arguments are considered equivalent/to have the same meaning, marks are awarded for the best response only. Zero is awarded for the other response.

For each argument:	
Very good argument - clear understanding demonstrated	3 marks
Fair argument - limited understanding	2 marks

Question 14 **38 (20, 18) marks**

(a) **20 (4, 2, 2, 6, 6) marks**

(i) **4(2,1,1) marks**

- **Any piece of hardware used to convey information from the computer to the user e.g. screen/monitor, printer/plotter, speaker/headphones, web cam, secondary storage devices etc.**

Very good description - clear understanding demonstrated	2 marks
Fair description – limited understanding	1 mark
For each correct example:	
Valid output device	1 mark

(ii) **2 marks**

(a) Decode
(b) Execute

For each correct response 1 marks
Award 1 mark for the correct names in the wrong order

(iii) **2 marks**

- **The Program Counter (PC) contains the address of the next instruction to be executed whereas the Accumulator (ACC) is used to store data to be operated on.**
- **The PC is typically located as part of the control unit whereas the ACC is typically found in the Arithmetic Logic Unit.**
- **Any valid difference.**

Very good explanation - clear understanding demonstrated	2 marks
Fair explanation - limited understanding	1 mark

(iv) **6(3,3) marks**

<u>Arithmetic Logic Unit (ALU)</u>

The purpose of the ALU is to perform all the basic arithmetic and logical operations.

<u>Control Unit (CU)</u>

The overall purpose of the CU is to direct and coordinate most of the operations in the computer. It instructs the memory, logic unit, and both output and input devices of the computer on how to respond to the program's instructions.

For each component:

Very good description - clear understanding demonstrated	3 marks
Fair description – limited understanding	2 marks

(v) **6(3,3) marks**

- **Number of cores. A processing unit within a CPU is known as a core. Each core is capable of fetching, decoding and executing its own instructions. The more cores a CPU has, the greater the number of instructions it can process in a given space of time.**
- **Clock speed. Clock speed is the number of pulses the CPU's clock generates per second. It is measured in hertz. The more pulses per second, the more fetch-decode-execute cycles that can be performed and the more instructions that are processed in a given space of time.**
- **Cache. A cache is a fast, relatively small capacity set of locations that is built directly within the processor. Cache is used to store the instructions and data that the processor is most likely to need and reuse. The bigger its cache, the less time a processor has to wait for instructions to be fetched.**
- **RAM. This is the short-term memory of the computer that holds all of the programs and data currently being ran by the computer. Having more memory means that the data and instructions that need to be processed will not have to be fetched from secondary storage (which is a much slower process).**
- **Temperature. If CPU gets too hot performance will decrease.**
- **Any other valid response (e.g. word size, bus width etc.)**

For each factor:

Very good description - clear understanding demonstrated	3 marks
Fair description – limited understanding	2 marks

(b) **18 (3, 3, 6, 6) marks**

(i) **3 marks**

Reasons for choosing solid state over magnetic hard drives

- **SSD is smaller, faster, quieter**
- **SSD has no moving parts - more reliable, durable, better for transportation, etc.**
- **SSD is completely electronic - consumes less power**
- **SSD is safe from magnets**

Reasons for choosing magnetic over solid state hard drives

- **Cheaper (cost per gigabyte is significantly less) and therefore greater capacity**
- **Data can be overwritten directly on the disk (there is a limit to the number of times SSDs can be written)**
- **Magnetic drives have been around longer and are therefore a more proven technology**

Very good justification - clear understanding demonstrated	3 marks
Fair justification – limited understanding	2 marks

(ii) **3 marks**

- **Virtual memory is an area of secondary storage (hard drive) that is allocated (by the operating system) to store data from RAM temporarily (usually when RAM is full)**
- **Data in virtual memory takes longer to be accessed and therefore processed as it is no longer in RAM.**

Very good explanation - clear understanding demonstrated	3 marks
Fair explanation - limited understanding	2 marks

(iii) **6(3,3) marks**

Cloud Advantages

- **Mobility and accessibility – available 24/7 from anywhere (assumes internet connectivity).**
- **Supports collaboration.**
- **Automatic back-up and restoration of data.**
- **Low setup costs (typically)**
- **Unlimited storage capacity.**
- **Security – looked after by cloud service provider.**

Cloud Disadvantages

- **Internet Connectivity**
- **Vendor lock-in**
- **Subscription/maintenance costs can become high**
- **Limited Control**
- **Security – out of your control**

For each advantage and disadvantage:

Very good description - clear understanding demonstrated	3 marks
Fair description - limited understanding	2 marks

(iv) **6(3,3) marks**

- **Typical activities of a Business Analyst (BA) include:**
  - **Identify areas within a business that need improvement. This can involve getting all the information about the current processes that a business follows and researching the market thoroughly to understand all possible solutions.**
  - **Creating presentations and reports to support communicating details about the required improvements/system requirements. The BA would typically present it in front of the board, staff, and every person directly involved with the proposed system.**
  - **Work as part of the development team – communicate system requirements to systems analysts (who develop the functional specifications), designers and programmers and testers.**
  - **Organise staff training to ensure everyone is ready to adapt to the changes and incorporate them into the system smoothly. The BA will ensure that the new system fits in with the current business model.**

Note: Where two separate responses are considered equivalent/to have the same meaning, marks are awarded for the best response only. Zero is awarded for the other response.

For each activity:

Very good description - clear understanding demonstrated	3 marks
Fair description - limited understanding	2 marks

Question 15 **38 (12, 11, 15) marks**

(a) **12(2,2,2,3,3) marks**

(i) **2 marks**

- **Linear search because the list is short/search is relatively fast on short lists.**
- **Binary search because the list is already sorted/search is faster.**

Note: No marks for identifying the search algorithm with no or invalid justification

Valid justification for the search algorithm named	2 marks

(ii) **2 marks**

Amir, Dean, Eoin, Helen, Natalia

Full correct response	2 marks
All names except Natalia listed	1 mark

(iii) **2 marks**

Helen, Steve, Natalia

Full correct response	2 marks
All names except Natalia listed	1 mark

(iv) **3(1,1,1) marks**

	Best Case	Worst Case
Linear Search	O(1)	**O(N)**
Binary Search	**O(1)**	$\boldsymbol{O(\log_2 N)}$

Each correct response 1 mark

(v) **3 marks**

O(1) time complexity means that the time needed to perform a certain task remains constant regardless of the size of the input, N.

Very good description - clear understanding demonstrated	3 marks
Fair description - limited understanding	2 marks

(b) **11(5,3,3) marks**

(i) **5(1,1,3) marks**

- **Start line number: 6**
- **End line number: 14**
- **The loop repeatedly divides the list in half by calculating the middle index. It compares the value at the middle index with the target value and updates the lower and higher indices accordingly until the target value is found or the search range becomes empty (indicated by the lower index crossing over the higher index).**

Correct response for start line number	1 mark
Correct response for end line number	1 mark
Explanation:	
Very good explanation - clear understanding demonstrated	3 marks
Fair explanation - limited understanding	2 marks

(ii) **3 marks**

- **The purpose of a return statement is to end the function**
- **To pass the result of the function back to the calling code.**

Very good explanation - clear understanding demonstrated	3 marks
Fair explanation - limited understanding	2 marks

(iii) **3 marks**

It is used to indicate that the value has not been found.

Very good explanation - clear understanding demonstrated	3 marks
Fair explanation - limited understanding	2 marks

(c) **15 (6, 6, 3) marks**

(i) **6(3,3) marks**

Recursive functions have the following three properties:

- **A recursive function must call itself. The program context for each call is placed on the call stack. Examples of this can be found on lines 9 and 11 of the code provided in the question.**
- **A recursive function must have a base case/exit criteria which triggers the end of the recursion. The base case is the smallest problem that can be solved directly without further recursion.**
  In the example code the base case is arrived at when lo > hi (line 3).
- **Progressive approach. A recursive algorithm must move towards its base case. In the example code this is achieved by the use of mid-1 and mid+1 to reset the values of lo and hi in each recursive call (lines 9 and 11).**

For each property:

Very good description - clear understanding demonstrated	3 marks
Fair description - limited understanding	2 marks

(ii) **6(3,3) marks**

Advantages

- **The main benefits of a recursive approach are simplicity, elegance and conciseness**
- **Recursion can lead to more readable and efficient algorithm descriptions.**
- **Recursion lends itself well breaking problems down into smaller similar problems**

Disadvantages

- **Performance. Recursion can lead to slower execution time due to memory overheads**
- **If recursion is too deep, then there is a danger of running out of space on the stack and ultimately program crashes.**

For each advantage/disadvantage:

Very good description - clear understanding demonstrated	3 marks
Fair description - limited understanding	2 marks

(iii) **3 marks**

```
result = binary_search2("Natalia", names, 0, len(names)-1)
```

Full correct response	3 marks
Almost correct response	2 marks
Response of some merit	1 mark

Section C — Programming — 80 marks

Question 16 — **80 (50, 30) marks**

(a) — **50 (10,10, 5, 5, 10, 10) marks**

Possible solution:

```
1  # Question 16(a)
2  # Examination Number:
3  from random import randint
4
5  def guess_game(max_guesses_allowed):
6
7      # (v) - start
8      difficulty = input("Enter difficulty E(asy) or H(ard): ")
9      if difficulty.upper() == "H":
10         secret_number = randint(1, 100)
11     else:
12         secret_number = randint(1, 5)
13     # (v) - end
14     guess_count = 0
15     user_guess = 0
16     guesses = [] # (vi)
17
18     while (user_guess != secret_number) and (guess_count < max_guesses_allowed): #
       (iii)
19
20         user_guess = int(input("Enter your guess: "))
21         guess_count += 1
22
23         # (vi) - start
24         if user_guess in guesses:
25             print("You already guessed this number.")
26         guesses.append(user_guess)
27         # (vi) - end
28
29         if user_guess == secret_number:
30             print("Congratulations! You win!")
31             print("You took", guess_count, "guesses") # (i)
32         # (ii) - start
33         elif user_guess < secret_number:
34             print("Sorry! Your guess was too low")
35         else:
36             print("Sorry! Your guess was too high")
37         # (ii) - end
38
39 print("Welcome to the guessing game!")
40 # (iv) - start
41 num_guesses_allowed = int(input("Enter the maximum number of guesses allowed: "))
42 guess_game(num_guesses_allowed)
43 # (iv) - end
```

(i) **10 marks (B-10 scale)**

10 marks	**Correct response** Correct implementation using solution above or similar.
7 marks	**Almost correct response** Correct implementation using solution above or similar but with minor syntax or semantic error.
3 marks	**Response with some merit** Any other reasonable attempt.

(ii) **10 marks (B-10 scale)**

10 marks	**Correct response** Correct implementation using solution above or similar.
7 marks	**Almost correct response** Correct implementation using solution above or similar but with minor syntax or semantic error.
3 marks	**Response with some merit** Any other reasonable attempt.

(iii) **5 marks (B-5 scale)**

5 marks	**Correct response** Correct implementation using solution above or similar.
3 marks	**Almost correct response** Correct implementation using solution above or similar but with minor syntax or semantic error.
2 marks	**Response with some merit** Any other reasonable attempt.

(iv) **5 marks (B-5 scale)**

5 marks	**Correct response** Correct implementation using solution above or similar.
3 marks	**Almost correct response** Correct implementation using solution above or similar but with minor syntax or semantic error.
2 marks	**Response with some merit** Any other reasonable attempt.

(v) **10 marks (C-10 scale)**

10 marks	**Correct response** Correct implementation using solution above or similar.
7 marks	**Almost correct response** Correct implementation using solution above or similar but with minor syntax or semantic error.
5 marks	**Response about half-right** Partially correct implementation using solution above or similar but with significant syntax or semantic error.
3 marks	**Response with some merit** Any other reasonable attempt.

(vi) **10 marks (C-10 scale)**

10 marks	**Correct response** Correct implementation using solution above or similar.
7 marks	**Almost correct response** Correct implementation using solution above or similar but with minor syntax or semantic error.
5 marks	**Response about half-right** Partially correct implementation using solution above or similar but with significant syntax or semantic error.
3 marks	**Response with some merit** Any other reasonable attempt.

(b) **30 marks**

Possible solution:

```
1   # Question 16(b)
2   # Examination Number:
3
4   from random import randint
5
6   user_score = 0 # a variable to keep track of the user's score
7
8   # Keep looping until the break statement is executed ...
9   # ... this will happen when the does not wish to play another round
10  while True:
11
12      secret_number = randint(1, 100) # generate the secret number
13      user_guess = int(input("Enter your guess: ")) # get the user's guess
14
15      # calculate the absolute difference between the user's guess and the secret
    number
16      difference = abs(user_guess-secret_number)
17      print("Secret number is %d. You guessed %d. Difference is %d" %(secret_number,
    user_guess, difference))
18
19      # Calculate the score based on how close the user's guess is to the secret
    number ...
20      # ... the closer the guess the more points the user/player gets
21      if user_guess == secret_number: # both numbers are the same ...
22          user_score += 100 # ... increase the score by 100 and ...
23          print("JACKPOT!!! You score 100 points") # ... tell the user
24      elif difference < 20: # if the difference is less than 20 ...
25          user_score += 20  # ... increase the score by 20 and ...
26          print("You score 20 points") # ... tell the user
27      elif difference > 30: # if the difference is more than 30 ...
28          user_score -= 30 # ... decrease the score by 30 and ...
29          print("Your lose 30 points")  # ... tell the user
30
31      # display a message with the total score at the end of each round
32      print("Your total score is:", user_score)
33
34      play_again = input("Play again? (y/n): ") # prompt the user to play again
35      if play_again.lower() != "y":
36          break
37
```

	High level of achievement **All** of the following implemented correctly and efficiently	**Moderate level of achievement** Reasonable attempt to implement at least two of each of the following	**Low level of achievement** Poor attempt to complete any of the following
Programming Standards (5 marks)	• Program executes correctly with no syntax or runtime errors • Program meets requirements • Program design is well explained with comments • Meaningful variable/function names (5 marks)	• Program executes correctly with no syntax or runtime errors • Program meets requirements • Program design is well explained with comments • Meaningful variable/function names (4 marks)	• Program executes correctly with no syntax or runtime errors • Program meets requirements • Program design is well explained with comments • Meaningful variable/function names (3 marks)
Program Inputs (5 marks)	• Computer correctly generates random number between 1 and 100 • User correctly prompted to enter guess • User correctly prompted to play again • Variable initialisation and use of assignment statements (5 marks)	• Computer correctly generates random number between 1 and 100 • User correctly prompted to enter guess • User correctly prompted to play again • Variable initialisation and use of assignment statements (4 marks)	• Computer correctly generates random number between 1 and 100 • User correctly prompted to enter guess • User correctly prompted to play again • Variable initialisation and use of assignment statements (3 marks)
Program Logic (Processing) **(10 marks)**	• Game loop / "Play again" logic • Logic to determine score on each round • Total scores correctly calculated (10 marks)	• Game loop / "Play again" logic • Logic to determine score on each round • Total scores correctly calculated (7 marks)	• Game loop / "Play again" logic • Logic to determine score on each round • Total scores correctly calculated (5 marks)
Program Outputs (10 marks)	• Message to display secret number, user's guess and difference • Message to display the outcome of the round • Message to display total score at the end of each round (10 marks)	• Message to display secret number, user's guess and difference • Message to display the outcome of the round • Message to display total score at the end of each round (7 marks)	• Message to display secret number, user's guess and difference • Message to display the outcome of the round • Message to display total score at the end of each round (5 marks)

Coursework (90 marks in total)	
1. Meeting the Brief	***Marks***
• Meeting the basic requirements of the brief. • Meeting the advanced requirements of the brief.	**27**
2. Investigation and Plan	
• Research into the context of the brief, existing solutions and initial thoughts on your own project. • A detailed description of the chosen project and the objectives.	**14**
3. Design	
• A clear detailed description of how the project will be developed. • A flowchart diagram to show how the project will work. • A description of how abstraction and modelling will be applied.	**14**
4. Implementation	
• An overview covering the key milestones of the development process. • Explain a problem that was encountered in the development of the project and how it was overcome. • An explanation of a piece of code or algorithm that was important in the development of the project.	**14**
5. Testing	
• An overview of the testing carried out. • A detailed test case table.	**11**
6. Evaluation	
• An evaluation of your project based on your initial design and your project objectives. • Suggest how you would further improve/iterate this project.	**10**
References and Summary word count	
• You must also include references and/or a bibliography. • Include a summary of the word count of the report, including the total word count.	**0**

Higher grade	Ordinary grade	Reference Mark	Higher Mark	Ordinary Mark
1		81 – 90	81 – 90	90
2		72 – 80	72 – 80	90
3		63 – 71	63 – 71	90
4		54 – 62	54 – 62	90
5	1	45 – 53	45 – 53	81 – 90
6	2	36 – 44	36 – 44	72 – 80
7	3	27 – 35	27 – 35	63 – 71
8	4	23 – 26	23 – 26	54 – 62
	5	18 – 22	18 – 22	45 – 53
	6	14 – 17	14 – 17	36 – 44
	7	9 – 13	9 – 13	27 – 35
	8	0 – 8	0 – 8	0 - 26

COURSEWORK – conversion from reference mark to Ordinary-level mark

For Ordinary-level candidates, the final mark is found from the reference mark as follows:

- If the reference mark is 54 or more the final mark is 90.
- If the reference mark is at least 27 but less than 54, then add 36 to the reference mark to get the final mark.
- If the reference is at least 1 but less than 27, then double the reference mark and add 9 to get the final mark.
- If the reference mark is 0 the final mark is 0

Reference Mark	Conversion
54 or more	Award 90 marks
27 – 53	Add 36 marks
1 - 26	Multiply the reference mark by 2 and add 9 marks
0	0