2023L219A1EL

Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate Examination 2023

Computer Science

Sections A & B

Higher Level

Wednesday 24 May Morning 9:30 - 11:00

130 marks

Examination Number

Day and Month of Birth

For example, 3rd February is entered as 0302

For Examiner use only								
Section	**Question**	**Mark**	**Section**	**Question**	**Mark**	**Section**	**Question**	**Mark**
A	1		A	7		B	13	
	2			8			14	
	3			9			15	
	4			10		**Section B Total:**		
	5			11		C	16	
	6			12		**Section C Total:**		
Section A Total:						**Total:**		

Instructions

There are **three** sections in this examination. Section A and B appear in this booklet. Section C is in a separate booklet that will be provided for the computer-based element.

Section A	Short Answer Questions	Attempt any nine questions All questions carry equal marks	54 marks
Section B	Long Questions	Attempt any two questions All questions carry equal marks	76 marks
Section C	Programming	Answer all question parts	80 marks

Calculators may **not** be used during this section of the examination.

The superintendent will give you a copy of page 78 (Logic gates) of the *Formulae and Tables* booklet on request. You are not allowed to bring your own copy into the examination.

Write your answers for Section A and Section B in the spaces provided in this booklet. There is space for extra work at the end of the booklet. Label any such extra work clearly with the question number and part.

Section A — Short Answer Questions — 54 marks

Answer any **nine** questions.

Question 1

Enter the appropriate data type in Column B to match the values in Column A.

Column A Value	Column B Data Type
Ciara	
255	
083-1234567	
1.5, 1.7, 1.2, 0.9, 1.3	
False	
−99.99	

Question 2

Information systems can represent numbers in decimal, binary and hexadecimal format. Many software developers use hexadecimal numbers.

(a) Explain **one** advantage of using hexadecimal numbers.

(b) Convert the hexadecimal number C9 into a decimal number.

Question 3

The diagram in **Figure 1** below, shows the Cartesian plane divided into four quadrants by an x-y axis, centred on the point (0, 0).

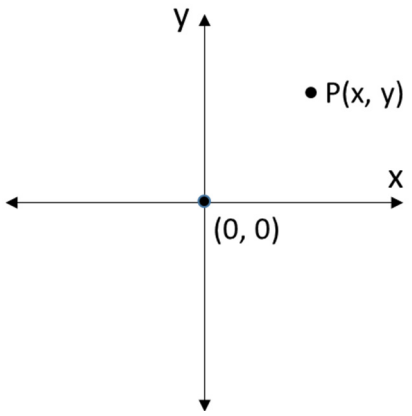


Figure 1

(a) A point `P(x, y)` is plotted inside the top right quadrant, as shown. Complete the truth table below to verify that `P` is inside the top right quadrant.

`x > 0`	`y > 0`	`x > 0 and y > 0`
`False`	`False`	`False`
`False`	`True`	
`True`	`False`	
`True`	`True`	

(b) Construct a Boolean expression in the space below that will evaluate to `True` for all points `(x, y)` inside the shaded area shown in **Figure 2**.

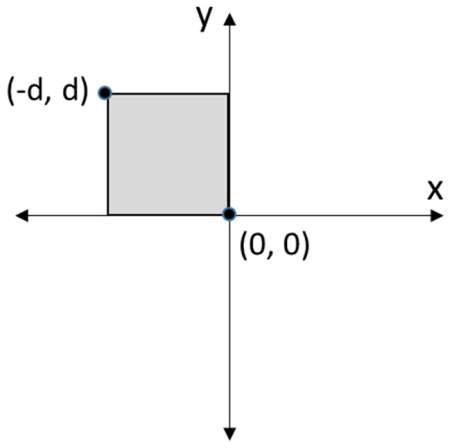


Figure 2

Question 4

User interfaces have evolved constantly over the past 40 years to become more user-friendly and accessible.

(a) What is meant by the term 'user interface'?

(b) Name and describe **one** type of user interface that a computer system might use.

Name:
Description:

Question 5

Transmission Control Protocol / Internet Protocol (TCP/IP) refers to a suite of protocols used to send and receive messages over the internet. The TCP/IP protocol suite contains a number of different layers. Name **one** of these layers and describe what happens within this layer.

Layer Name:
Layer Description:

Question 6

Smart homes make use of embedded systems to make living spaces more enjoyable and convenient for home owners.

(a) State **two** examples of embedded systems you might find in a smart home.

1.
2.

(b) Describe **two** characteristics of embedded systems that distinguish them from general computer systems.

1.
2.

Question 7

Complete the trace table for the Python code shown below.

```
1  x = 10
2  y = 5
3
4  while x >= y:
5      x = x - 1
6      y = y + 1
```

x	y
10	5

Question 8

A farmer needs to ferry a wolf, a goat and a cabbage from one side of a river to the other in a boat, as shown in **Figure 3**. However, the boat only has room for the farmer and one other item, either the wolf, the goat or the cabbage. If left alone without the farmer present, the wolf would eat the goat, and the goat would eat the cabbage.

Figure 3

The state of the system at any given point in time can be represented using an ordered list of four values as follows:

`(<side for farmer>, <side for wolf>, <side for goat>, <side for cabbage>)`

By using the letter `E` to represent the east side of the river, and the letter `W` to represent the west side of the river, the state `(E, E, E, E)` means that all four are on the east side of the river.

`(E, E, E, E)` is the initial state of the system.

(a) Using this notation, what is the desired final state of the system?

(b) The state `(W, E, E, W)` is considered a loss state because the wolf will eat the goat (as the farmer and the cabbage are both on the west side).

(i) Using this notation, name any other **two** loss states.

1.
2.

(ii) Using this notation, name any **one** non-loss state, other than the initial and final states.

Question 9

Chop Cup is a magic routine which involves three cups face down and one ball underneath one of the cups. In any single move the position of two cups can be swapped using one of three possible moves, `A`, `B` or `C` as shown in **Figure 4** below.

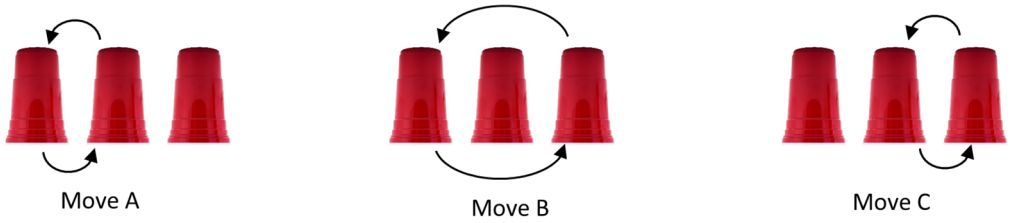


Figure 4

Each cup is identified by its position. Initially the leftmost cup is at position 1, the middle cup is at position 2 and the right cup is at position 3.

(a) Given that the ball starts under the leftmost cup (position 1) and always remains under the same cup, state the ball position after the sequence of moves, `ABCBCA`.

(b) Without knowing which cup the ball is under, construct a sequence involving at least three moves which results in the ball ending in the same position as it started from.

Question 10

Quicksort is widely recognised as one of the most efficient sorting algorithms. It works by recursively partitioning a list about one of the elements known as the pivot. Consider the unsorted list of integers shown in **Figure 5** below and answer the questions that follow.

60	30	80	40	10	50	20	70	90

Figure 5

(a) Using the leftmost element as the pivot, show the contents of the list after the initial partition by the quicksort algorithm. You should assume that the elements in the left and right sub-lists are not re-ordered.

(b) Explain why 90 would have been a poor choice of pivot to partition the list shown in **Figure 5**.

Question 11

Figure 6 depicts a flowchart of a Python algorithm which can be used to generate new usernames for students. You can assume that the date is in the format: ddmmyyyy.

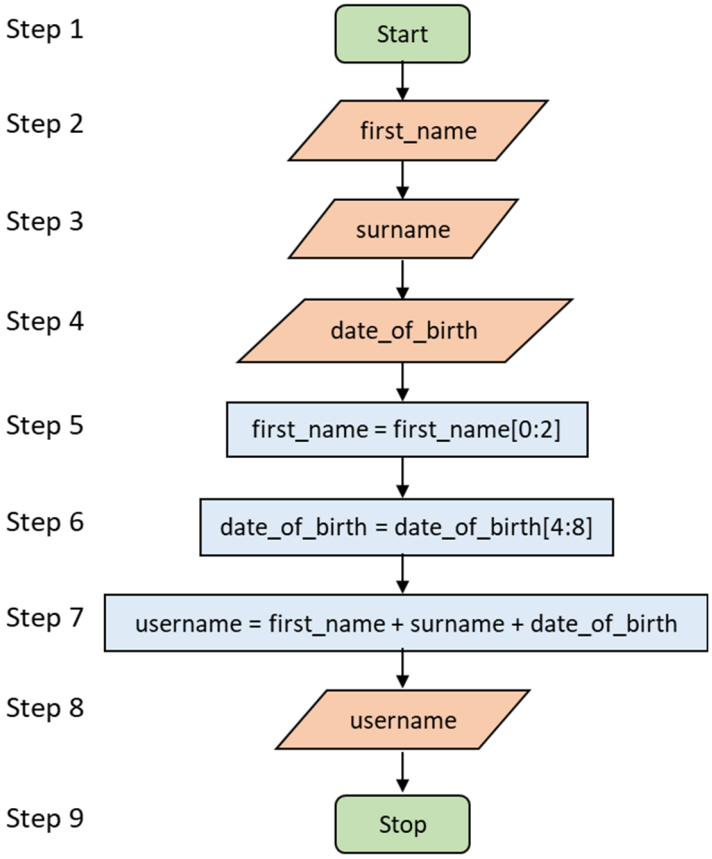


Figure 6

(a) Name **one** input and **one** output of the algorithm.

Input:
Output:

(b) Referring to the relevant step(s) in the flowchart explain how the algorithm uses string slicing and string concatenation.

String slicing:
String concatenation:

Question 12

A Software Development Lifecycle (SDLC) such as the one shown in **Figure 7** below, is usually followed when creating information systems.

Figure 7

(a) Outline briefly **two** reasons why the SDLC is important.

Reason 1:
Reason 2:

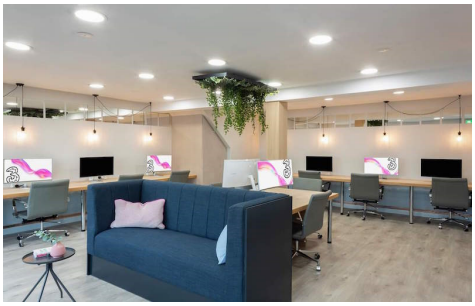
(b) Distinguish between functional and non-functional testing.

Section B	Long Questions	76 marks

Answer any **two** questions.

Question 13

The National Hub Network is an initiative set up by the Irish Government to allow people across Ireland to work closer to home through providing digital working hubs with modern facilities and high-speed internet connections. There are over 260 working hub locations spread across Ireland with over 4000 desks available. Many of these hubs have been set up in rural and remote areas.



(a)

(i) Consider the impact that a digital working hub might have to a rural community's culture and society. Provide **one** argument in support of this initiative and **one** argument against.

Support:
Against:

(ii) As the demand for desk space in digital hubs increases, the Government plan on using computer modelling to plan ahead and make sure they have enough resources in place and also that they are targeting the correct areas when it comes to opening new hubs. Suggest **one** data item that could be collected in order to model the situation. Justify your answer.

Item:
Justify:

This question continues on the next page.

(iii) To ensure that the digital hubs are accessible for anyone who wishes to use them, adaptive and assistive technologies are in place for anyone who should need them. Name **two** types of such technologies and describe how each could support someone with additional needs when using a computer system.

Technology 1:
Description:
Technology 2:
Description:

(b) **Figure 8** shows the set of hubs and distances in kilometres between each pair of hubs. A technician must travel around each hub to check the equipment and to fix any technical issues that arise. The technician will begin at Hub A and visit all hubs exactly once, before returning to Hub A.

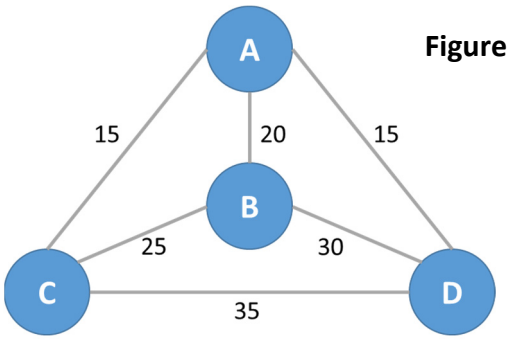


Figure 8

(i) Calculate and state the shortest possible route the technician should take.

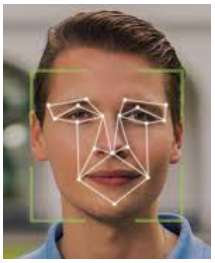
(ii) Outline briefly **two** features of abstraction contained in **Figure 8**.

Feature 1:
Feature 2:

This question continues on the next page.

(iii) At the beginning of each day the technician has a look at all of the locations that she needs to visit. To try and do this in the shortest time possible the technician will use heuristics. Explain what is meant by heuristics.

(c) In 2022, the Irish Government announced plans to introduce legislation to grant Gardaí new powers to use Facial Recognition Software (FRS). However, the Irish Council for Civil Liberties (ICCL) said it strongly opposes the use of such technology for law enforcement and in public spaces.



Outline **two** arguments for and **two** arguments against the use of FRS for law enforcement.

For 1:
For 2:
Against 1:
Against 2:

Question 14

In the 1940s John von Neumann discovered that computer systems could treat instructions as data and, as such, could be manipulated inside the computer's memory while a program is running. This major breakthrough in computing became known as the stored program concept, and is still used in the majority of computer systems we use today. The von Neumann architecture is shown in **Figure 9**.

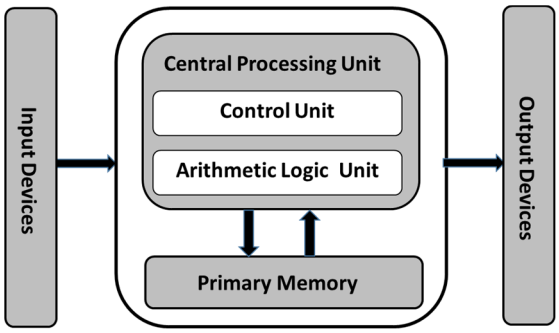


Figure 9

(a)

(i) Explain the term 'output device'. Provide **two** examples.

Explain:
Example 1:
Example 2:

(ii) The CPU cycle carried out to process data and instructions has three steps to it. The first step 'Fetch Instruction' has been completed for you in **Figure 10** below. Complete the diagram by filling in the next **two** steps of the process, labelled **(a)** and **(b)**.

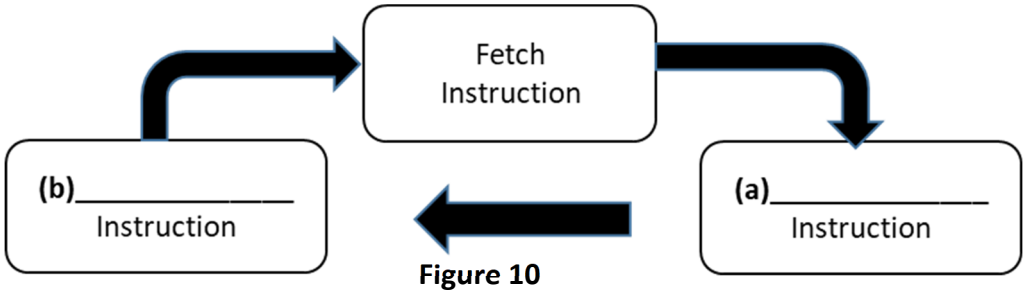


Figure 10

(iii) The CPU contains a number of registers including the Program Counter and the Accumulator. Explain **one** difference between these two registers.

This question continues on the next page.

(iv) The CPU is often described as the brains of the computer. It is made up of two main components, namely the Arithmetic Logic Unit (ALU) and the Control Unit (CU). State the purpose of these **two** components.

ALU:
CU:

(v) The CPU is the most important component of a computer system and determines how fast a computer can run. Describe **two** factors that can impact the performance of the CPU.

1.
2.

(b) As well as having main memory, computer systems tend to have secondary storage which allows users to save data such as programs and files.

(i) Sarah is looking to buy a new laptop. So far, all the laptops she has looked at have either magnetic or solid state hard drives. Which type of secondary storage would you recommend? Justify your answer.

Recommendation:
Justify:

This question continues on the next page.

(ii) When a computer is carrying out lots of tasks it can start to run out of memory. In some cases, a computer may have to rely on virtual memory. What is meant by the term 'virtual memory'?

(iii) For a school software development project Sarah has to work with classmates to produce a computational artefact for a local business. The group will be working on this both at school and at home. Sarah suggests working in the cloud for the project. Describe **one** advantage and **one** disadvantage of working in the cloud.

Advantage:
Disadvantage:

(iv) As part of the school project Sarah has been assigned the role of Business Analyst. Describe **two** activities typically undertaken by a Business Analyst in a software development company.

Activity 1:
Activity 2:

Question 15

Computers can use a choice of different search algorithms to find information much quicker than humans. Two common search algorithms are the linear search and the binary search.

(a) Consider the following list of seven names.

Amir	Dean	Eoin	Helen	Natalia	Steve	Terry

(i) What search algorithm would be best suited to search the list of names shown above? Justify your answer.

Search Algorithm:
Justify:

Search algorithms work by comparing the list elements with a particular search value, known as a key.

(ii) List, in order, the names that would be compared until *Natalia* is found using the linear search algorithm.

(iii) List, in order, the names that would be compared until *Natalia* is found using the binary search algorithm.

(iv) Complete the table below to show the best and worst case time complexities for the two search algorithms. You can assume that the size of the input is N.

	Best Case	**Worst Case**
Linear Search	O(1)	
Binary Search		

(v) What is meant by O(1) time complexity?

This question continues on the next page.

(b) The Python code below shows an implementation of a binary search function.

```
1  def binary_search1(v, L):
2
3      lo = 0
4      hi = len(L) - 1
5
6      while (lo <= hi):
7          mid = (lo + hi)//2
8
9          if L[mid] > v:
10             hi = mid - 1
11         elif L[mid] < v:
12             lo = mid + 1
13         else:
14             return mid
15
16     return len(L)
```

(i) In the code there is one example of iteration. State on which lines the iteration starts and ends and explain what it does.

Start line number:
End line number:
Explain:

(ii) The function contains two examples of a `return` statement – line 14 and line 16. What is the purpose of a `return` statement?

(iii) Explain the reason for `len(L)` on line 16.

This question continues on the next page.

(c) An alternative implementation of the binary search can be achieved using recursion as shown.

```
1  def binary_search2(v, L, lo, hi):
2
3      if lo > hi:
4          return len(L)
5
6      mid = (lo + hi)//2
7
8      if L[mid] > v:
9          return binary_search2(v, L, lo, mid-1)
10     elif L[mid] < v:
11         return binary_search2(v, L, mid+1, hi)
12
13     return mid
```

(i) Referring to the code above, describe **two** properties of recursive functions.

Property 1:
Property 2:

(ii) State **one** advantage and **one** disadvantage of using recursion.

Advantage:
Disadvantage:

(iii) Given a list of names, initialised as shown below, write a line of code to call the function `binary_search2` to find the name *Natalia*. You should store the result of the function in a variable called `result`.

```
names = ["Amir", "Dean", "Eoin", "Helen", "Natalia", "Steve", "Terry"]
```

Space for extra work.

Indicate clearly the number and part of the question(s) you are answering.

Space for extra work.

Indicate clearly the number and part of the question(s) you are answering.

Space for extra work.

Indicate clearly the number and part of the question(s) you are answering.

Acknowledgements

Images
Image on page 5: https://www.ccnahub.com/ip-fundamentals/understanding-tcp-ip-and-osi-models/
Image on page 7: https://www.researchgate.net/figure/On-the-left-is-the-Wolf-Goat-and-Cabbage-puzzle-environment-Right-screenshot-from-a_fig2_305084487
Image on page 11: https://devoxsoftware.com/blog/software-development-lifecycle/
Image on page 12: https://www.donegaldaily.com/2021/05/12/making-remote-work-an-office-with-a-view-on-arranmore/
Image on page 14: https://skybiometry.com/the-best-face-recognition-software-for-your-business/

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