



Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate Examination 2022

Computer Science

Sections A & B

Higher Level

Wednesday 25 May Morning 9:30 - 11:00

60 marks

Examination Number

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Day and Month of Birth

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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:	

The 2022 examination papers were adjusted to compensate for disruptions to learning due to COVID-19.
This examination paper does not necessarily reflect the same structure and format as the examination papers of past or subsequent years.

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 six questions All questions carry equal marks	30 marks
Section B	Long Questions	Attempt any one question All questions carry equal marks	30 marks
Section C	Programming	Answer all question parts	50 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.

Answer any six questions.

Question 1

What is the output of the following Python program?

```
1 def func(a):
2     a = a + 1
3     b = 15
4     print(a)
5     print(b)
6     return(a)
7
8 a = 5
9 b = 10
10 print(a)
11 b = func(a)
12 print(a)
13 print(b)
```

Output:

Question 2

Registers and RAM are both types of volatile memory.

(a) What is volatile memory?

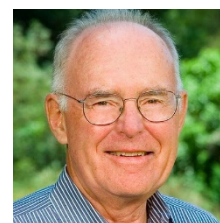
This question continues on the next page.

(b) Describe **two** differences between registers and RAM.

1.
2.

Question 3

In 1965 Gordon Moore, co-founder of Intel Corporation, predicted that the number of transistors on an integrated circuit will approximately double every two years. This prediction became known as Moore's Law and has turned out to be very accurate to the present day.



(a) Explain the terms transistor and integrated circuit.

Transistor:
Integrated circuit:

(b) State **one** reason why Moore's Law might not remain accurate in the future.

Question 4

An automatic garage door has three inputs:

- A, the master ON/OFF switch
- B, a sensor on the left hand side
- C, a sensor on the right hand side

Once the master switch has been set ON, either sensor can trigger the door. This scenario can be represented by the logical statement: $A \text{ AND } (B \text{ OR } C)$.



(a) Complete the truth table for the logical statement $A \text{ AND } (B \text{ OR } C)$.

A	B	C	$A \text{ AND } (B \text{ OR } C)$
0	0	0	0
0	0	1	0
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

(b) Use the relevant gate symbols to draw the circuit diagram for this system.

Blank area for drawing the circuit diagram.

Question 5

A chemical solution is said to be an acid if its pH level is less than 7, a base if its pH level is greater than 7, and neutral otherwise.

Figure 1 displays a flowchart of an algorithm that, for a given pH entered by the user, displays whether it is an acid, a base or neutral.

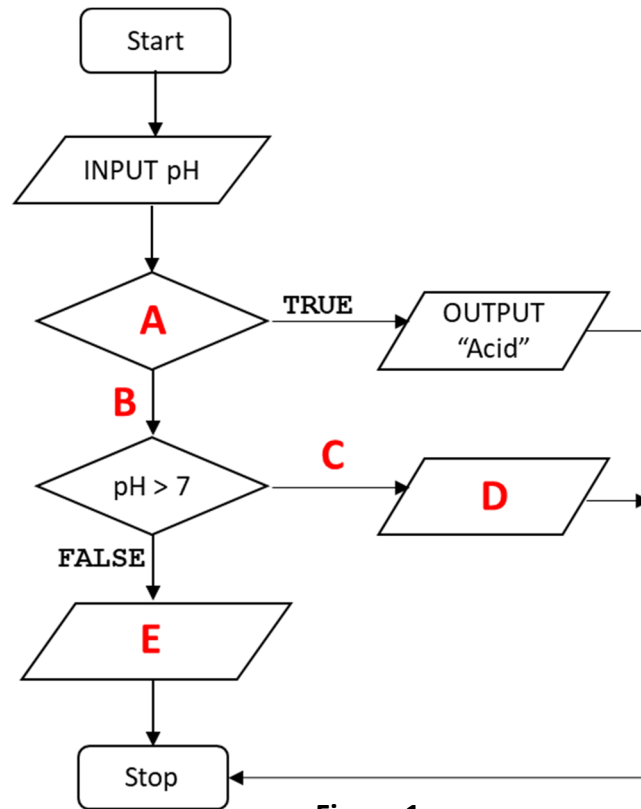


Figure 1

Complete the table below to indicate the text that should appear in the flowchart for the letters A-E.

Letter	Missing Text
A	
B	
C	
D	
E	

Question 6

Figure 2 shows an example of the client-server model of computing.

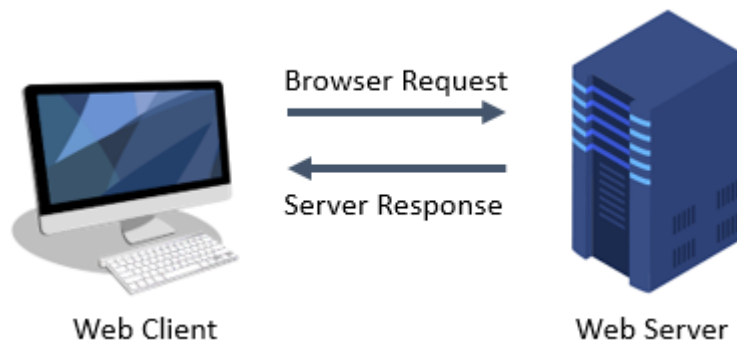


Figure 2

Explain the client-server model of computing. In your answer you should make reference to the terms included in **Figure 2**.

Question 7

On 14 May 2021, the Health Service Executive (HSE) of Ireland suffered a major ransomware cyberattack which caused all of its IT systems nationwide to be shut down.

(a) Explain the term ransomware.

This question continues on the next page.

(b) State **two** measures individuals or companies can take to reduce the risk of a cyberattack.

1.
2.

Question 8

Cloud computing has been described as the third wave of the digital revolution.

Outline **one** advantage and **one** disadvantage of cloud computing under the headings of both cost and impact on the environment.

Cost (advantage):
Cost (disadvantage):
Environment (advantage):
Environment (disadvantage):

Question 9

(a) Provide **two** examples of how machine learning can be used to benefit society.

1.
2.

(b) Outline briefly the issue of 'bias' in relation to machine learning.

Question 10

You have eight coins and a two pan scales. Both the coins and the scales are gold plated and the diameter and circumference of all the coins are exactly the same. The coins are worth €2 each, a total of €16.

- seven of the coins are genuine and weigh the same amount.
- one of the coins is fake and is heavier than the others.



(a) Explain a way that the fake coin can be found in the minimum number of weighings.

This question continues on the next page.

(b) Outline briefly your use of abstraction to tackle this problem.

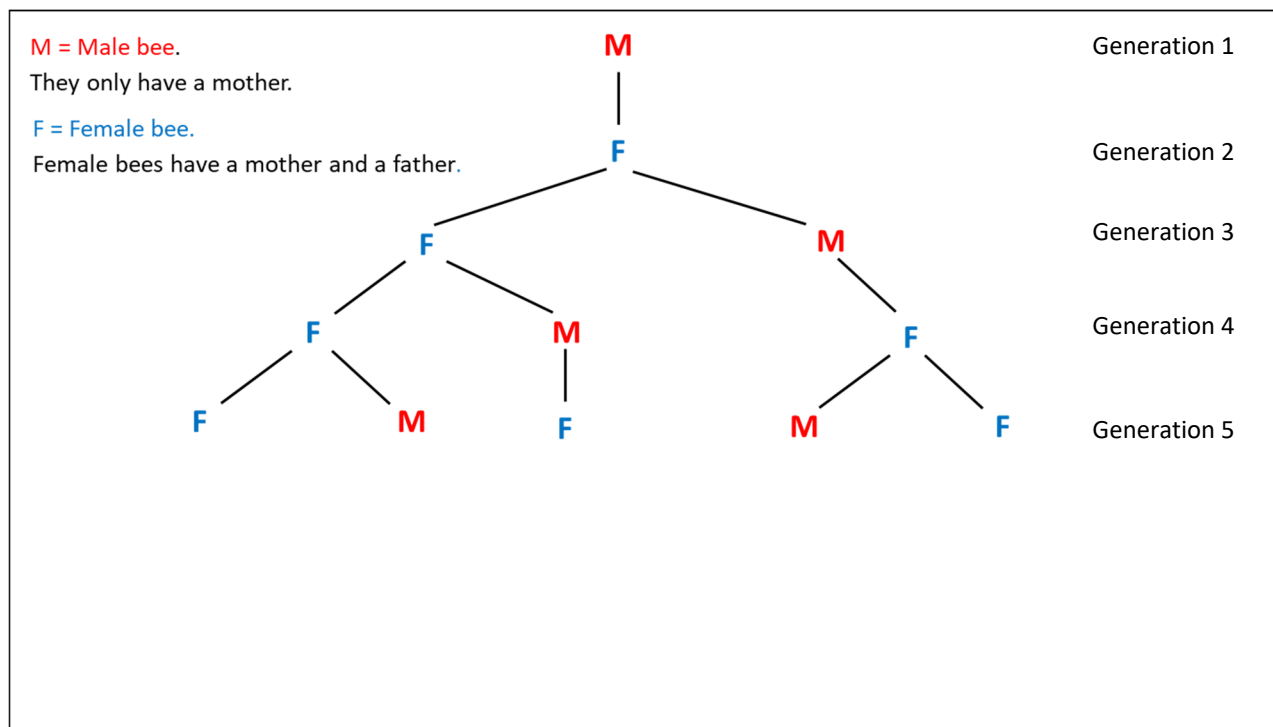
Question 11

The reproduction rules for honey bees are quite remarkable. Females lay eggs and if an egg is fertilised by a male it will hatch as a female. Unfertilised eggs hatch as males.

The illustration below shows an ancestry tree for the male honey bee shown at the top of the tree. There are five generations shown.



(a) Draw and label **two** additional generations.



(b) Describe any pattern emerging that could be used to model the number of bees in any particular generation.

Question 12

The state transition diagram for a particular Turing machine is shown in **Figure 3** below.

The initial state is S_0 and the initial tape contents is the binary number 0110 followed by a blank, represented by 'B'. The final state is S_3 .

Trace the computation of the Turing machine by filling in the blanks in the diagram below. The read/write head is currently reading a 0. You can assume that the read/write head is moved one place to the right at the end of each step.

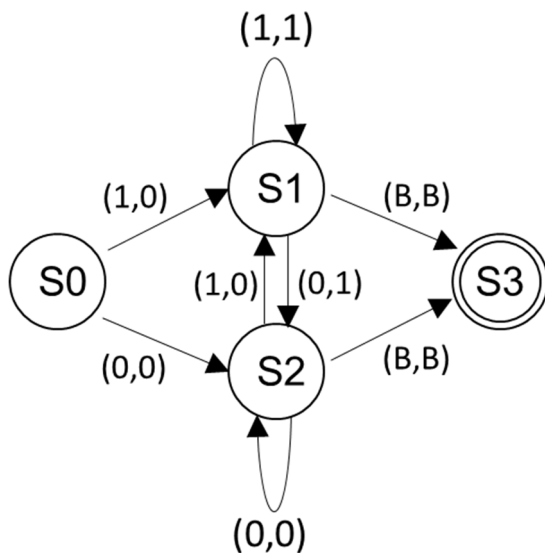


Figure 3

State	Tape
S0	... 0 1 1 0 B ... ↑
	
	
	
	
	

Answer any one question.

Question 13

K-9 Kennels is a small dog boarding business whose aim is to meet the needs of dog owners who often have difficulty in finding a safe and reliable place to leave their pets. Since it was established, owners John and Mary Chewit have worked tirelessly to grow the business, and in addition to boarding it now offers a range of other services including grooming, massage and training.



- (a) Mary and John realise that they need an information system and have appointed the software company you work for to design and develop the system. An initial meeting has been arranged and your manager has asked you to attend.

- (i) What is an information system?

- (ii) Provide **two** examples of how an information system could benefit K-9 Kennels.

1.
2.

- (iii) Identify **two** key stakeholders and their respective roles in relation to the new system.

Stakeholder 1:
Role:
Stakeholder 2:
Role:

This question continues on the next page.

- (iv) Outline briefly **two** topics relating to the project which you anticipate will be discussed at the initial meeting.

1.
2.

- (v) John and Mary are unsure about whether their system should be a website or a mobile application. State whether you think John and Mary should opt for a web application or a mobile application. Provide **two** reasons for this choice.

Choice:
Reason 1:
Reason 2:

- (vi) Explain why the choice of software development process is important when it comes to designing and developing software systems.

This question continues on the next page.

- (b)** Some weeks after the initial meeting John and Mary contact your company to request that an online store be included as part of the system. The store will be made up of two pages – a shop page and a checkout page.
- (i)** The shop page should allow visitors to browse items. When a visitor wishes to purchase an item, they should be able to click an 'Add to Cart' button.

Create a wireframe diagram to show the layout of the shop page. Your wireframe should include annotations outlining the purpose of the main elements.



This question continues on the next page.

- (ii) Describe **two** user-centred design features you would use in the design of your system for John and Mary.

1.
2.

- (iii) State **two** differences between wireframes and prototypes.

1.
2.

- (iv) The checkout page will allow users to enter their delivery and payment details in order to finalise their order.

Provide **one** example of each of the following types of data that the system should collect on the checkout page.

String:
Integer:
Boolean:

Question 14

- (a) A simplified version of the selection sort algorithm involves the use of two lists called `list1` and `list2`. At the start of the algorithm the elements in `list1` are unsorted, and `list2` is empty as shown.

<code>list1:</code>	15	28	14	21
<code>list2:</code>				

At the end of the algorithm `list1` is empty, and `list2` contains the elements that were in `list1` at the start, now sorted in *ascending* order.

<code>list1:</code>				
<code>list2:</code>	14	15	21	28

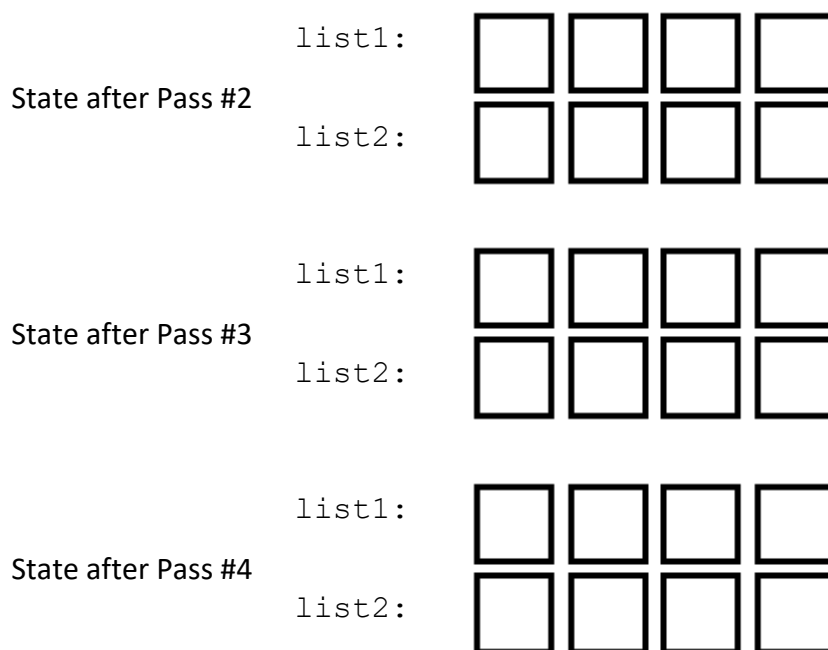
The algorithm is described by the following pseudo-code:

1. Let `N` be the number of elements in `list1`
2. Initialise an empty list of length `N` - call this `list2`
3. Repeat `N` times:
4. Select the smallest (minimum) element from `list1`
5. Move the smallest element from `list1` to `list2`
6. Stop

- (i) Apply the algorithm to sort the list of integers [15, 28, 14, 21] showing the state of both lists after each pass of the algorithm. Pass #1 has been completed for you. You only need to fill in the numbers for passes 2, 3 and 4.

Initial State	<code>list1:</code>	15	28	14	21
	<code>list2:</code>				
State after Pass #1	<code>list1:</code>	15	28		21
	<code>list2:</code>	14			

This question continues on the next page.



- (ii) The algorithm sorts the list in ascending order. What changes would you need to make to the algorithm so that it sorts the list in *descending order*?

- (iii) Step 4 of the algorithm says to select the smallest (minimum) element from `list1`. Outline a method to find the smallest element in any list.

This question continues on the next page.

- (iv) Step 5 of the algorithm says to *move* the smallest element from `list1` to `list2`. Why would the algorithm not work if this step said to *copy* the smallest element from `list1` to `list2`?

- (v) The algorithm relies on two lists to complete the sort. Describe a selection sort algorithm that would sort a list 'in place' i.e. without the need for a second list.

This question continues on the next page.

- (b) A bookshelf is partially sorted, in alphabetic order, using the insertion sort algorithm as shown in **Figure 4** below.

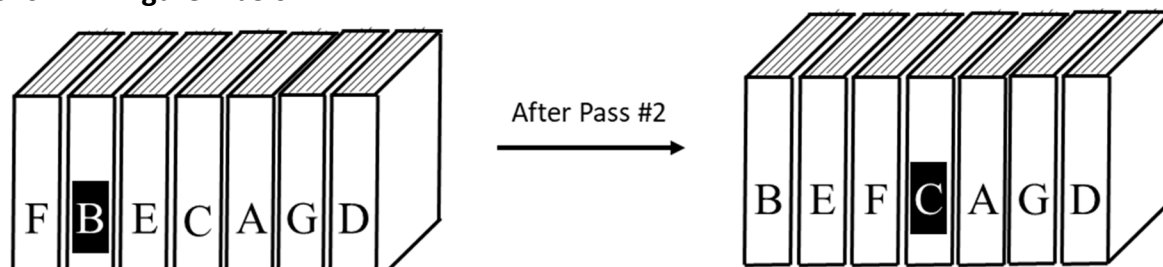


Figure 4

- (i) Fill in the empty boxes below to complete passes 3, 4, 5 and 6 of the insertion sort.

Initial List:	F	B	E	C	A	G	D
After Pass #1:	B	F	E	C	A	G	D
After Pass #2:	B	E	F	C	A	G	D
After Pass #3:							
After Pass #4:							
After Pass #5:							
After Pass #6:							

- (ii) Explain how the insertion sort algorithm works.

This question continues on the next page.

- (iii) A list that is already reversed would be considered a good test case for the insertion sort algorithm. Describe **two** other test cases that could be used to test the insertion sort algorithm.

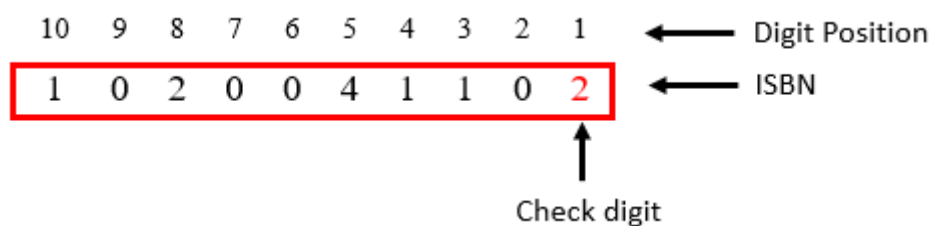
Test case 1:
Test case 2:

- (iv) "Big O" notation is used to describe the complexity of an algorithm. Discuss the algorithmic complexity of the insertion sort algorithm using "Big O" notation.

Question 15

A check digit is a single digit number used to verify numbers such as barcodes, credit cards and International Standard Book Numbers (ISBNs), thereby helping to prevent data entry errors.

Check digits usually appear as the rightmost digit (position 1) of a number. For example, the check digit of the ISBN number, 1020041102 highlighted here is 2.



The general procedure used to verify ISBN numbers is as follows:

Step 1: Multiply each digit in the number by its own digit position.

Step 2: Add the 10 results together.

Step 3: Divide the total by 11.

Step 4: If the remainder is zero the ISBN number is deemed to be valid.

(a) Apply the above procedure to verify that the ISBN number 1020041102 is valid.

This question continues on the next page.

- (b) Given a 9-digit number, the Python program below can be used to find the number's check digit, that will be used as the 10th digit.

```
1 # A program to determine a check digit for a number
2 isbn = "102004110"
3 total = 0
4 for i in range(10, 1, -1):
5     total = total + int(isbn[10-i]) * i
6
7 check_digit = 11 - (total % 11)
8 print("The check digit for", isbn, "is", check_digit)
```

- (i) Line 1 of the above program contains a comment.
State **two** reasons why programmers use comments.

Reason 1:
Reason 2:

- (ii) The program makes use of a number of variables and data types.
Explain the terms variable and data type using **one** example of each from the code.

Variable:
Data type:

- (iii) The program makes use of the Python `int` function.
Outline the purpose of the `int` function as it is used in the code.

This question continues on the next page.

- (iv) The `range` function on line 4 of the program generates a sequence of every integer from 10 down to 1 (but not including 1). Describe **one** way these integers are used in the program.

- (c) The Python program below shows an alternative implementation.

```

1  # A program to determine a check digit for a number
2  isbn = 102004110
3  isbn1 = isbn
4  total = 0
5  for i in range(2, 11):
6      digit = isbn % 10
7      total = total + digit*i
8      isbn = isbn//10
9
10 check_digit = 11 - (total % 11)
11 print("The check digit for", isbn1, "is", check_digit)

```

- (i) Complete the trace table below to show the changing states of the variables during program execution.

i	digit	total	isbn
		0	102004110
2	0	0	10200411
3	1	3	1020041
4	1	7	102004
5	4	27	10200
6	0	27	1020
7			
8			
9			
10			

This question continues on the next page.

(ii) What is the purpose of the variable called `isbn1` in the program?

(iii) The program makes use of a number of arithmetic operators. State the purpose of each of the operators listed below.

%
//

(iv) Identify **two** key differences between the algorithms used in parts (b) and (c).

Difference 1:
Difference 2:

(v) Provide an example of **one** type of data entry error a check digit could be used to prevent.

Space for extra work.

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

[illegible]

Space for extra work.

Indicate clearly the number and part of the question

[illegible]

Space for extra work.

Indicate clearly the number and part of the question

[illegible]

Acknowledgements

Images

Image on page 4: <https://www.forbes.com/profile/gordon-moore/>

Image on page 5: <https://www.indiamart.com/proddetail/automatic-garage-door-18064248973.html>

Image on page 10: <https://www.beeculture.com/catch-the-buzz-why-vegans-avoid-honey/>

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Leaving Certificate – Higher Level

Computer Science – Sections A & B

Wednesday 25 May

Morning 9:30 – 11:00



Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate Examination 2022

Computer Science

Section C

Higher Level

Wednesday 25 May Morning 11:30 – 12:30

50 marks

Do not hand this up.
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Instructions

There is one section in this paper.

Section C	Programming	One question	50 marks
		Answer all question parts	

Answer all parts of the question on your digital device.

Calculators may be used during this section of the examination.

The *Formulae and Tables* booklet cannot be used for this section of the examination.

The superintendent will give you a copy of the *Python Reference Guide*.

Ensure that you save your work regularly.

Save your files using the naming structure described at the beginning of the question.

If you are unable to get some code to work correctly, you can comment out the code so that you can proceed. The code that has been commented out will be reviewed by the examiner.

Rough work pages are provided at the end of this booklet. Please note that this booklet is not to be handed up and will **not** be reviewed by an examiner.

At the end of the examination it is your responsibility to ensure that you have saved your file onto your external media.

You will be provided with a brown envelope for your external media. Write your examination number on this envelope and place your external media into it before sealing. Place this envelope in the pouch at the front of the red envelope that contains your examination booklet from Section A and B.

There is no examination material on this page

Answer all question parts.

Question 16

- (a) Open the program called **Question16_A.py** from your device. The source code is shown below.

Before making any changes, you should save your working copy of the file using the format **ExaminationNumberQuestion16_A.py**. For example, you would save the file as **123456Question16_A.py** if your Examination Number was 123456.

Enter your Examination Number in the space provided on **line 2** in your Python file.



The program simulates the rolling of a die 100 times.

The result of each roll (throw) is stored in a variable called `throw_result`. Each of the 100 results are appended to a list called `results` as they are generated.

The program also contains code to keep track of the number of times a one and a two are rolled. These are stored in a list called `frequencies`.

```
1  # Question 16(a)
2  # Examination Number:
3  from random import randint
4
5  print("Dice simulation program")
6  results = []
7  frequencies = [0, 0, 0, 0, 0, 0]
8
9  # Loop 100 times
10 for i in range (100):
11     throw_result = randint(1,6) # store a random value between 1 and 6
12     results.append(throw_result) # append each value to results
13
14     # Start to build up a list of frequencies for each value thrown
15     if throw_result == 1:
16         frequencies[0] = frequencies[0] + 1
17     elif throw_result == 2:
18         frequencies[1] = frequencies[1] + 1
19
20 print()
21 print("Results:", results)
```

This question continues on the next page.

When the program is run, the output may look as follows:
(Your output will be different because the dice numbers are generated randomly.)

```
Dice simulation program
```

```
Results: [1, 4, 1, 4, 2, 3, 2, 2, 2, 4, 3, 1, 6, 1, 3, 3, 5,
1, 1, 3, 2, 2, 4, 1, 6, 4, 4, 5, 2, 2, 4, 2, 1, 2, 4, 2, 6, 6,
5, 4, 3, 5, 5, 1, 1, 6, 5, 1, 3, 3, 5, 3, 1, 5, 3, 5, 3, 2, 1,
1, 1, 1, 4, 2, 5, 6, 4, 3, 4, 6, 4, 5, 2, 5, 5, 3, 1, 5, 4, 3,
2, 2, 6, 2, 2, 3, 3, 2, 3, 1, 5, 2, 5, 4, 6, 4, 3, 5, 5, 2]
```

Make the following changes to the program:

- (i) Currently the first line in the program output is *Dice simulation program*.

Change the program so that the first line in the output is *Dice simulation and analysis program*.

When the program is run the output may now look as follows:

```
Dice simulation and analysis program
```

```
Results: [1, 4, 1, 5, 3, 6, 2, 6, 6, 1, 3, 6, 4, 5, 1, 2, 5,
3, 5, 6, 5, 6, 5, 3, 3, 3, 4, 1, 2, 6, 1, 2, 4, 4, 6, 2, 4, 6,
5, 3, 4, 6, 4, 1, 4, 5, 6, 1, 1, 3, 5, 6, 6, 1, 2, 2, 5, 4, 3,
2, 6, 2, 2, 2, 2, 1, 2, 3, 4, 3, 3, 4, 3, 1, 6, 4, 1, 2, 4, 1,
3, 4, 1, 5, 3, 3, 5, 4, 4, 1, 2, 4, 4, 5, 6, 5, 6, 1, 5, 3]
```

- (ii) Insert a new line of code at the end of the program to display the list of dice frequencies.

When the program is run the output may now look as follows:

```
Dice simulation and analysis program
```

```
Results: [1, 3, 5, 1, 5, 1, 2, 4, 2, 5, 5, 5, 6, 4, 1, 1, 6,
4, 2, 1, 2, 6, 5, 3, 6, 5, 3, 6, 3, 3, 2, 1, 4, 2, 3, 4, 6, 6,
3, 3, 6, 5, 6, 6, 6, 5, 3, 2, 1, 3, 3, 6, 1, 4, 2, 5, 6, 4, 2,
1, 6, 6, 6, 4, 2, 2, 4, 5, 6, 3, 2, 6, 2, 2, 3, 3, 3, 1, 5, 6,
3, 6, 2, 5, 5, 1, 4, 5, 4, 1, 5, 4, 6, 4, 4, 5, 3, 3, 1, 4]
Frequencies: [14, 15, 0, 0, 0, 0]
```

The frequencies list tells us that the number one has been rolled 14 times and the number two has been rolled 15 times.

The frequencies for the numbers three, four, five and six are not calculated by the program yet. This is the reason they are all zero.

This question continues on the next page.

- (iii) Complete the code to calculate the frequencies for the numbers three, four, five and six.

When the program is run the output may now look as follows:

```
Dice simulation and analysis program

Results: [2, 4, 6, 2, 1, 4, 1, 3, 1, 3, 3, 6, 5, 5, 4, 3, 2,
2, 2, 1, 3, 4, 4, 3, 4, 6, 4, 2, 3, 1, 3, 3, 1, 5, 3, 3, 6, 5,
4, 6, 1, 5, 3, 4, 2, 1, 6, 6, 5, 2, 6, 4, 5, 2, 2, 6, 6, 5, 5,
6, 2, 3, 5, 6, 4, 1, 6, 2, 2, 6, 2, 6, 3, 3, 4, 2, 5, 5, 5, 3,
1, 2, 3, 4, 2, 6, 2, 1, 5, 6, 6, 2, 5, 2, 3, 2, 5, 2, 2, 6]
Frequencies: [11, 23, 18, 13, 16, 19]
```

In this case the frequencies list tells us that the number one has been rolled 11 times, the number two has been rolled 23 times, the number three has been rolled 18 times, the number four has been rolled 13 times, the number five has been rolled 16 times and the number six has been rolled 19 times.

- (iv) Comment out the line that displays the list of individual results.

When the program is run the output may now look as follows:

```
Dice simulation and analysis program

Frequencies: [17, 21, 17, 18, 11, 16]
```

- (v) Extend the program to display the frequency of each number in a tabular format as shown in the sample output here.

```
Dice simulation and analysis program

Frequencies: [15, 10, 25, 15, 15, 20]
Dice Frequency
----
1      15
2      10
3      25
4      15
5      15
6      20
```

This question continues on the next page.

- (vi) Extend the program so that it determines and displays the number that was rolled most often along with its frequency. For example, in the output below the number five was rolled most often (25 times). You can ignore the possibility of ties.

When the program is run the output may now look as follows:

```
Dice simulation and analysis program

Frequencies: [16, 14, 12, 20, 25, 13]
Dice Frequency
-----
1      16
2      14
3      12
4      20
5      25
6      13

5 was rolled the most often (25 times)
```

- (vii) Extend the program to display a horizontal bar chart of the frequencies.

The number of asterisks (*) in each row should correspond to each frequency. For example, in the output below there are eight asterisks in row one because the frequency for the number one is eight.

Each asterisk (*) can be printed using the single statement: `print("*", end="")`

When the program is run the output may now look as follows:

```
Dice simulation and analysis program

Dice frequencies: [8, 12, 22, 26, 22, 10]
Dice Frequency
-----
1      8
2     12
3     22
4     26
5     22
6     10

4 was rolled most often - 26 times

*****
*****
*****
*****
*****
*****
```

Save your file using the format **ExaminationNumberQuestion16_A.py**. For example, you would save the file as **123456Question16_A.py** if your Examination Number was 123456.

Space for rough work.

This page will not be reviewed by an examiner.

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Leaving Certificate – Higher Level

Computer Science – Section C

Wednesday 25 May

Morning 11:30 – 12:30