2021L219A1EL

Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate Examination 2021

Computer Science

Sections A & B

Higher Level

Saturday 22 May Morning 9:30 – 11:00

60 marks

Examination number					

Centre stamp

For Examiner use only	
Section	**Mark**
A	
B	
C	
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 six questions All questions carry equal marks	30 marks
Section B	Long Questions	Attempt any one question	30 marks
Section C	Programming	One question 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.

Section A — Short Answer Questions — 30 marks

Answer any six questions.

Question 1

What is the output of the following piece of Python code?

```
1  x = 3
2  print("x is", x)
3
4  y = x
5  x = x+4
6  print(x, y)
7
8  x = y*2
9  print(x, 2**y)
10
11 y = x-y-1
12 print("y is y")
```

Output:

Question 2

(a) Explain why data is stored in computers in binary format.

This question continues on the next page.

(b) A single bit can be used to represent two pieces of information.

(i) How many unique pieces of information could be represented using four bits?

(ii) What is the minimum number of bits required to represent eight unique pieces of information?

Question 3

(a) State **two** differences between RAM and ROM.

1.
2.

This question continues on the next page.

(b) Explain how increasing the amount of RAM on a computer might improve its performance.

Question 4

You are asked to swap the values of two variables, `x` and `y`, which have already been initialised.

(a) Why does the method shown not work?

```
x = y

y = x
```

(b) Describe a method that does work.

Question 5

The flowchart in **Figure 1** is a representation of an algorithm.

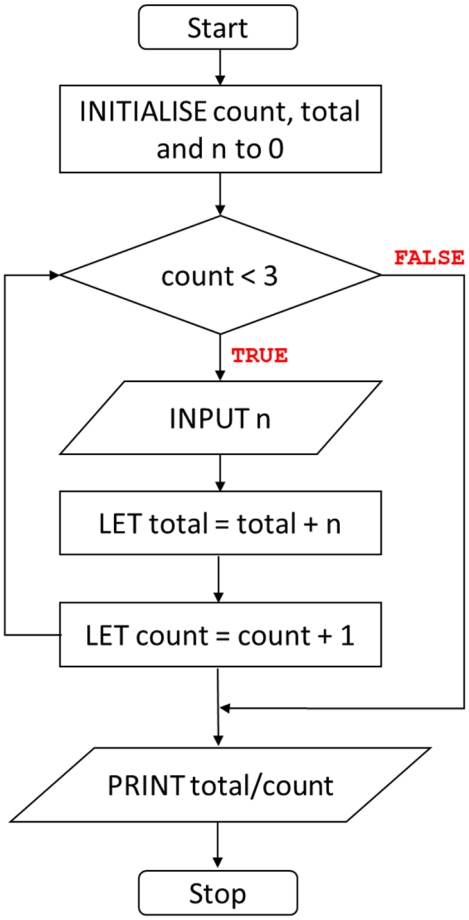


Figure 1

(a) Using inputs of 7, 3 and 8 for n, complete the trace table showing the execution of the algorithm.

n	total	count
0	0	0
7		
3		
8		

(b) What output does the algorithm display?

Question 6

You have been asked to assess an algorithm for a travel agent. The company gives discounts based on the number of people in a group.

The Python code below determines the type of discount to give based on the number of adults (`num_adults`) and the number of children (`num_children`) in a travelling group.

```
1  num_adults = int(input("Enter the number of adults: "))
2  num_children = int(input("Enter the number of children: "))
3
4  if num_adults > 1 and num_children > 0:
5      print("Family discount")
6  elif num_adults >= 10:
7      print("Large group discount")
8  elif num_adults >= 5:
9      print("Small group discount")
10 else:
11     print("No discount")
```

Describe **two** scenarios where the algorithm could be perceived to be unfair.

Scenario 1:
Scenario 2:

Question 7

(a) Differentiate between HTTP and HTTPS.

(b) Explain how the TCP communication protocol provides reliable communication between computers.

Question 8

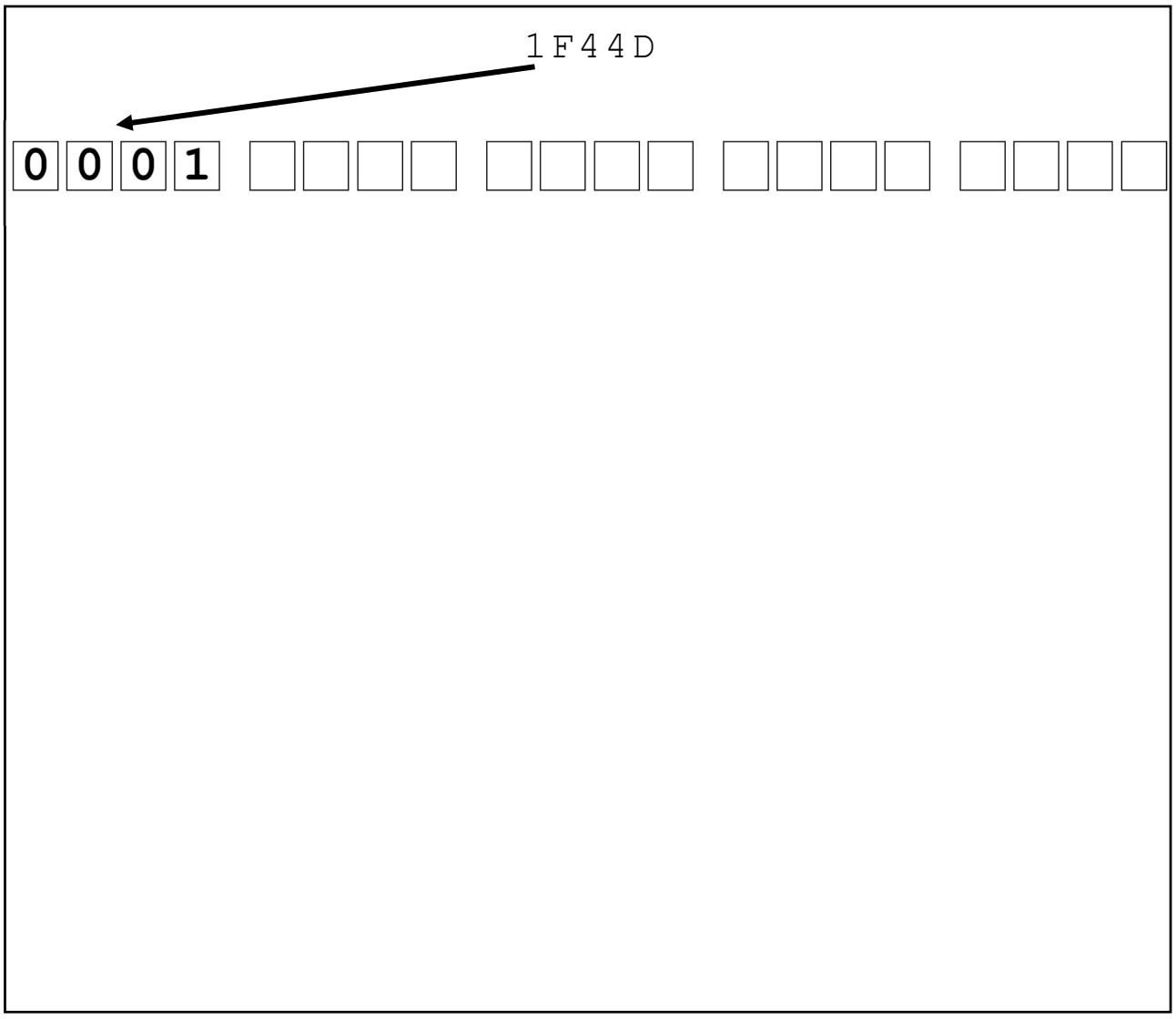
The Unicode representation for the 'thumbs up' emoji character, shown in **Figure 2**, is the hexadecimal number 1F44D.

Figure 2

(a) Explain why emoji characters are not represented using the American Standard Code for Information Interchange (ASCII).

This question continues on the next page.

(b) Express the hexadecimal number 1F44D as a binary number. The first four bits have been completed for you.



Question 9

(a) What is an operating system?

This question continues on the next page.

(b) The diagram in **Figure 3** depicts some of the main layers of an operating system. Select any **two** layers and explain their function.

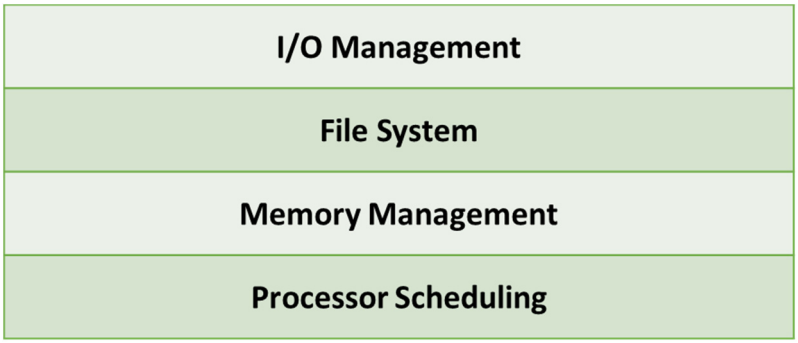


Figure 3

Layer 1:
Explain:
Layer 2:
Explain:

Question 10

(a) State **two** tasks that would be undertaken by a project manager in a software design process.

1.
2.

This question continues on the next page.

(b) Some programming roles require the knowledge of low-level programming. How does a low-level computer program differ from a high-level computer program?

Question 11

(a) State **two** benefits of computer modelling.

1.
2.

(b) Explain how agent-based modelling may have been used during the COVID-19 pandemic to influence public health policy.

Question 12

The following selection of data is taken from a table in a database used to store information about dogs.

dog_name	breed	dob	microchip
rover	labrador	22/11/2011	Y
fido	poodle	02/02/2020	Y
fido	jack russell	15/06/2015	N
champ	greyhound	01/01/2010	Y
spot	dalmation	24/08/2007	N
buddy	rottweiler	21/10/2012	Y

(a) State why each of the following fields would **not** be good candidates for a primary key in the table shown above.

dog_name:
breed:

(b) One owner can own many dogs. Explain how a foreign key could be introduced to improve the design of this database.

owner_id	owner_name	address	dog_name	breed	dob	microchip
1	Joe Murphy	1 main st.	rover	labrador	22/11/2011	Y
1	Joe Murphy	1 main st.	fido	poodle	02/02/2020	Y
2	Ada Traore	9 park ave.	fido	jack russell	15/06/2015	N
1	Joe Murphy	1 main st.	champ	greyhound	01/01/2010	Y
2	Ada Traore	9 park ave.	spots	dalmation	24/08/2007	N
3	James Tidy	7 bond st.	buddy	rottweiler	21/10/2012	Y

Section B	Long Questions	30 marks

Answer any one question.

Question 13

Eircode is the postal address code system used in Ireland to uniquely identify every individual address in the country. An Eircode is a seven-character code made up of two parts – a three-character Routing Key and a four-character Unique Identifier.

The first character in the Routing Key must always be a letter, and the second and third characters must always be digits.
Every character in the Unique Identifier must be alpha-numeric i.e. either a letter or a number.

The format of the Eircode, A65 F4E2, is shown below in **Figure 4**.

Figure 4

(a) Explain why each of the following are not valid Eircodes.

(i) GA5 AOK1

(ii) X234 Y56

(iii) 8XT A43Y

This question continues on the next page.

(b) The intention of the Python code shown below is to implement a validation check for an Eircode.

```
1  def is_valid_eircode(test_eircode):
2
3  # This function checks whether 'test_eircode' is a valid Eircode or not
4  # It returns True if 'test_eircode' is a valid Eircode. False otherwise.
5
6  # Uses:
7  #    s.isalpha() -> True if s contains alphabetic only; False otherwise
8  #    s.idigit()  -> True if s contains digits only; False otherwise
9  #    s.isalnum() -> True if s contains alpha-numeric only; False otherwise
10
11   if not test_eircode[0].isalpha():
12       return False
13
14   # if the second character isn't a digit or the third character isn't a
15   # digit the Eircode is invalid so return False
16   if ((not test_eircode[1].isdigit()) or (not test_eircode[2].isdigit())):
17       return False
18
19   if not test_eircode[-4:].isalnum():
20       return False
21
22   return True
```

(i) What is meant by the term 'validation check'?

(ii) Outline briefly how a test case could be used to test the above code.

This question continues on the next page.

(iii) Two types of testing that could be performed on the code are unit testing and system testing. Distinguish between these two types of testing.

(iv) This Python code will show that the Eircode, *A99 SP@M A1OK,* is valid even though it is not. Why does the code indicate that this Eircode is valid?

(v) After code has been changed it is important to conduct regression testing. Why is this important?

This question continues on the next page.

(c) The following questions are based on the code in part **(b)**.

(i) Explain what the following code does:

```
11  if not test_eircode[0].isalpha():
12      return False
```

(ii) Consider the following statement from line 16.

```
16  if ((not test_eircode[1].isdigit()) or (not test_eircode[2].isdigit())):
```

If we let `P` represent the possible boolean values for `test_eircode[1].isdigit()` and `Q` represent the possible boolean values for `test_eircode[2].isdigit()`, complete the truth table below for the expression, **`not P or not Q`**.

P	Q	not P	not Q	not P or not Q
False	False			
False	True			
True	False			
True	True			

(iii) Using the same meanings for P and Q from part **(ii)** complete the truth table below for the expression, **`not (P and Q)`**.

P	Q	P and Q	not (P and Q)
False	False		
False	True		
True	False		
True	True		

This question continues on the next page.

(iv) Use your findings from parts **(ii)** and **(iii)** to re-write the statement on line 16, without changing its logical meaning.

```
16 if ((not test_eircode[1].isdigit()) or (not test_eircode[2].isdigit())):
```

(v) Explain how the technique of string slicing could be used to provide an alternative to the statement on line 16.

```
16 if ((not test_eircode[1].isdigit()) or (not test_eircode[2].isdigit())):
```

Question 14

(a) Consider a two-player game in which each player takes alternate turns at removing matchsticks from a board. The rules of the game are simple:

- at each turn a player must remove either one or two matchsticks
- the player who takes the last matchstick wins

Winning and losing positions are defined in terms of the number of matchsticks left on the board.

A winning position (W) is a position from which a player cannot lose if she/he makes all the optimal moves until the end of the game. For example, 2 is a winning position because if the player whose turn it is, makes the optimal move (i.e. removes the two remaining matchsticks) they will win that game.

A losing position (L) is a position from which a player cannot win (assuming that their opponent makes all the optimal moves until the game is over).

The win/loss table below depicts winning and losing positions for the scenarios where there are 0, 1, 2, 3 or 4 matchsticks left on the board.

No. of matchsticks remaining	0	1	2	3	4
Position (W or L)	L	W	W	L	W

(i) Explain why 3 is a losing position.

(ii) Explain why 4 is a winning position.

This question continues on the next page.

(iii) Calculate whether 5 and 6 are winning or losing positions and place your answers in the table below.

No. of matchsticks remaining	0	1	2	3	4	5	6
Position (W or L)	L	W	W	L	W		

Calculations

(iv) Assume you are about to start a new game with 21 matchsticks. If your opponent offered you the choice of going first or second, which would you choose? Justify your answer.

(v) What strategy would you recommend in a game that started off with 20 matchsticks? Justify your answer.

This question continues on the next page.

(vi) Assume the rules of the game are amended so that players can remove 3 matches (as well as 1 or 2). Calculate whether or not each position in a game with 9 matchsticks is a winning or losing position and place your answers in the table below.

No. of matchsticks remaining	0	1	2	3	4	5	6	7	8	9
Position (W or L)	L									

Calculations

This question continues on the next page.

(b) Consider a variation of the game described in part **(a)** with two key differences: the matchsticks are initially arranged into two separate piles on the board and a player can remove any number of matchsticks from a single pile on their go. We will call the two piles pile X and pile Y.

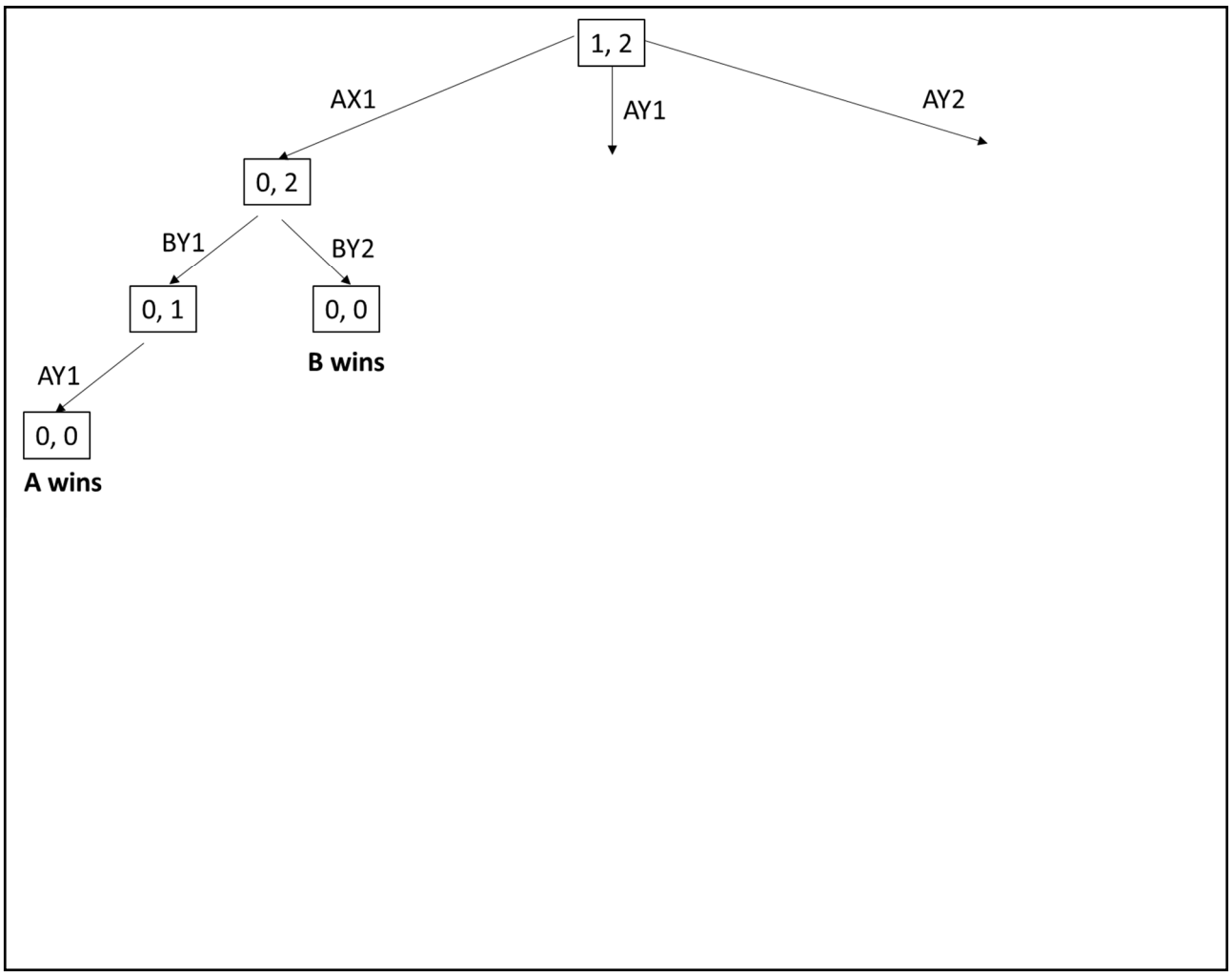
For example, in a game where pile X contains 10 matchsticks and pile Y contains 9 matchsticks, a player may decide to remove 9 matchsticks from pile Y on their go.

The player who removes the last matchstick(s) wins the game.

(i) Below is a partially completed diagram for an end game scenario in which it is player A's turn and there is only one matchstick left in pile X and two matchsticks left in pile Y (denoted by 1, 2).

The purpose of the diagram is to depict the eventual outcome for every possible move from this point in the game. The left-hand branch of the diagram has been completed covering all eventualities if player A removes 1 matchstick from pile X (denoted by AX1).

Complete the diagram to illustrate all possible moves and show who wins in each case.



This question continues on the next page.

(ii) Based on the completed diagram which is player A's best move? Why?

Player A's best move:
Reason:

(iii) Describe a winning move from state (2, 3).

(iv) Hence, or otherwise, describe a winning strategy from state (n, m), where $n \neq m$.

(v) Explain why (n, n, n) is a winning position in a game where 3 piles are used?

This question continues on the next page.

(c) Explain the use of any **one** of decomposition, abstraction or pattern recognition in developing solutions to problems such as those in parts **(a)** and **(b)**. You may refer to the solutions you used in answering parts **(a)** and **(b)**.

Question 15

(a) Charles Stark Draper is often credited with the invention of embedded systems.

Embedded systems are a combination of hardware and software designed to perform a specific function. They are called 'embedded' because they are often used as part of a larger system. Many embedded systems use sensors to receive analogue or digital inputs. The input data which is often supplied in real time is then processed resulting in some sort of output. While not every embedded system will have a user interface, some are designed to meet the principles of universal design.

(i) Explain the terms hardware and software. Provide **two** examples of each.

Hardware:
Example 1:
Example 2:

Software:
Example 1:
Example 2:

(ii) Provide **one** example of a digital sensor and **one** example of an analogue sensor.

Digital Sensor:
Analogue Sensor:

This question continues on the next page.

(iii) Explain, with the aid of a diagram, the difference between digital and analogue input.

Diagram:

(iv) In the context of embedded systems what is meant by the term ‘real-time’?

This question continues on the next page.

(v) Describe **two** advantages of embedded systems over general purpose computer systems, such as desktop computers and laptops.

1.
2.

(b) According to the description provided in part **(a)**, mobile devices such as smartphones and tablets could be considered to contain multiple embedded systems.

(i) Describe **two** examples of embedded systems on mobile devices.

1.
2.

This question continues on the next page.

(ii) In the context of mobile devices distinguish clearly between the terms, 'user interface' and 'universal design'.

(iii) State **two** principles of universal design. For each principle you should describe how it relates to the design of an embedded system of your choice.

Principle 1:
Describe:
Principle 2:
Describe:

This question continues on the next page.

(c) The market for embedded systems is likely to continue to grow for the foreseeable future as they are seen as key drivers of current and emerging trends in computing such as the Internet of Things (IoT), smart homes, smart cities, drones and surveillance technology.

Discuss the potential impact of embedded systems on society. In your answer you should provide evidence that you have considered alternative perspectives of any **two** stakeholders that you think are relevant.

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 8: www.iemoji.com/view/emoji/56/smileys-people/thumbs-up
Image on page 18: www.dreamstime.com/photos-images/pile-matches.html
Image on page 24: history.aip.org/phn/11506034.html

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