British Informatics Olympiad

CONFIDENTIAL before 31 January 2023

The 2023 British Informatics Olympiad Marking Scheme

Instructions for setting the 2023 British Informatics Olympiad

Students should each have a computer with their chosen programming language installed.

They should also each have a calculator, pen and paper, and an empty USB stick (or other storage device) on which to back up their work and save their solution programs.

If possible, please disable any network to prevent students from communicating. Students should not use the internet during the contest except where required to access the on-line help for their language.

Please allow the students a few minutes to carefully read the rubric; during this time they must not turn over the page and look at the questions. Please also encourage the students to read the questions first before attempting any answers.

The 3 hour time limit should start once you allow them to turn the page and begin the exam.

Marking instructions

For each competitor you should have a set of programs and a written paper. The programs for parts 1(a), 2(a) and 3(a) are to be tested by running them with data specified in this marks scheme – you do not need to look at their program code. The written answers can also be marked as specified here, without needing any specialist knowledge.

The program names used by competitors should be clearly marked on their papers. Failure to do this, or to compile programs where necessary, should not prevent programs being marked, but deduct [2] marks for every such program. Programs produced by the competitors to help in the written questions may be used in selecting the BIO 2023 finalists.

If a student gets a negative number of marks on any question, score that question as a 0.

Programs written for 1(a), 2(a) and 3(a) are to be 'black-box' tested: you should run the program, enter the given data and verify the solution. For each of these tests the data to be entered is given in **`bold text`**. The output format is flexible (there is no penalty for extra spaces etc.), but the solutions must be correct for marks to be scored. Input and output may appear in different windows.

Note that, if a program does not complete a test in 1 second of processing time, it should be interrupted and the rest of that test ignored. The other questions should be marked from the competitors' written answers.

All marks are given in square brackets by the test/answer they relate to. Answers not covered under the mark scheme should get no marks. In some cases details are given on how marks may be given for partial answers, as well as alternative answers which merit marks.

Accompanying this marks scheme are two forms to help you in grading the paper. The script cover sheet is designed to assist you with marking each student's answers and the marks submission sheet is to list the marks for all students.

Please **submit all your marks to us electronically** using the form at
https://www.olympiad.org.uk/2023/bio-mss-2023.html

Marks that are received after **15 January 2023** will not be considered for the final.

All programs and student scripts should be retained by you until at least 1 February as we may require them for moderation; you do *not* need to send us students' programs unless requested. After this date, you are free to return scripts to the students and distribute copies of the BIO 2023 exam paper.

Finally, thank you very much for participating in BIO 2023.

Question 1(a) [24 marks available]

For each test of the program for 1(a) you need to type in a single number. The output should be one or more numbers. All numbers in the output must be correct for the marks to be scored; numbers in the output *may* appear in any order.

Tests *must* terminate in 1 second to receive marks.

[1]	**100**	89 8 3
[2]	**1**	1
[2]	**832040**	832040
[2]	**4**	3 1
[2]	**623**	610 13
[2]	**12**	8 3 1
[2]	**834629**	832040 2584 5
[2]	**33**	21 8 3 1
[2]	**2023**	1597 377 34 13 2
[2]	**5000**	4181 610 144 55 8 2
[2]	**514228**	317811 121393 46368 17711 6765 2584 987 377 144 55 21 8 3 1

Additional marks are available for general program behaviour:

[1] Program inputs a number.
[1] For each a test one or more numbers are output.
[1] All tests terminate without without crashing / hanging.

Question 1(b) [2 marks available]

[2] 832,040

Question 1(c) [2 marks available]

[2] 18,424

Question 1(d) [4 marks available]

[4] 2,998,107,957

Question 2(a) [23 marks available]

There are 12 tests used to check 2(a). For each test you will need to type in a string consisting of two *capital* letters

For each test you should see a single integer, which needs to be correct to score marks.

Tests *must* terminate in 1 second to receive marks.

[1]	**FF**	7
[2]	**XX**	6
[2]	**TT**	8
[2]	**II**	10
[2]	**GX**	13
[2]	**QP**	14
[2]	**MW**	15
[2]	**ZY**	16
[2]	**NU**	16
[2]	**AS**	16
[2]	**JL**	18
[2]	**VI**	19

Question 2(b) [2 marks available]

[2] 1

Question 2(c) [5 marks available]

[2] `III` : 122
[3] `LIV` : 672

Question 2(d) [4 marks available]

[4] 84

(**Supplementary:** The answer 161 scores [3] marks)

Question 3(a) [23 marks available]

Each test for 3(a) consists of two lines, each containing four numbers. For each test you should see a single integer output.

There are no marks for incorrect answers, and tests *must* terminate in 1 second to receive marks.

[1]	`12 0 3 4` `1 32 4 0`	3
[2]	`12 0 34 0` `12 0 34 0`	0
[2]	`1 23 0 4` `1 2 0 43`	1
[2]	`1 2 3 4` `0 2 3 41`	1
[2]	`1 2 3 4` `1 3 2 4`	3
[2]	`4 3 2 1` `3 2 4 1`	4
[2]	`0 0 241 3` `0 4 1 32`	4
[2]	`0 4 0 123` `12 3 4 0`	5
[2]	`1234 0 0 0` `4 213 0 0`	6
[2]	`12 3 4 0` `21 0 34 0`	7
[2]	`1234 0 0 0` `0 0 0 1234`	7
[2]	`1234 0 0 0` `4321 0 0 0`	9

Question 3(b) [2 marks available]

[2] 288

Question 3(c) [5 marks available]

[2] After 2 moves, 73 states
[3] After 4 moves, 375 states

Question 3(d) [4 marks available]

The following numbers can be given in any order:

[4] 1, 1, 2, 3, 3, 3, 8, 8

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2023 British Informatics Olympiad
Script Cover Sheet

Please use this sheet, with reference to the marks scheme, to assist you with marking each student's script. As it summarises the solutions to many questions, **do not distribute or show this sheet to any contestant before 31 January 2023.**

Name of Student: Age: School Year:

1(a)

input	100	1	832040	4	623	12	834629	33	2023	5000	514228
	(1)	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*
output	89 8 3	1	832040	3 1	610 13	8 3 1	832040 2584 5	21 8 3 1	1597 377 34 13 2	4181 610 144 55 8 2	317811 121393 46368 17711 6765 2584 987 377 144 55 21 8 3 1

TOTAL 1(a) *(24)*

Inputs data? *(1)*
Valid output? *(1)*
Exits okay? *(1)*

1(b) *Ans: 832,040* *(2)*

1(c) *Ans: 18,424* *(2)*

1(d) *Ans: 2,998,107,957* *(4)*

2(a)

input	FF	XX	TT	II	GX	QP	MW	ZY	NU	AS	JL	VI
	(1)	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*
output	7	6	8	10	13	14	15	16	16	16	18	19

TOTAL 2(a) *(23)*

2(b) *Ans: 1* *(2)*

2(c) *Ans: 122 & 672* *(2)+(3)*

2(d) *Ans: 84* *(4)*

Suppl: [3] for 161

3(a)

input	12 0 3 4 1 32 4 0	12 0 34 0 12 0 34 0	1 23 0 4 1 2 0 43	1 2 3 4 0 2 3 41	1 2 3 4 1 3 2 4	4 3 2 1 3 2 4 1
	(1)	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*
output	3	0	1	1	3	4

3(a)

input	0 0 241 3 0 4 1 32	0 4 0 123 12 3 4 0	1234 0 0 0 4 213 0 0	12 3 4 0 21 0 34 0	1234 0 0 0 0 0 0 1234	1234 0 0 0 4321 0 0 0
	(1)	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*
output	4	5	6	7	7	9

TOTAL 3(a) *(23)*

3(b) *Ans: 288* *(2)*

3(c) *Ans: 73 & 375* *(2)+(3)*

3(d) *Ans: 1, 1, 2, 3, 3, 3, 8, 8* *(4)*

Deduct [2] marks for every part (a) program name that is not clearly marked on the script, or where the student has failed to compile the program for languages that require compiling.

Marked By:

TOTAL Q1	***TOTAL Q2***	***TOTAL Q3***
(32)	*(34)*	*(34)*

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Marks Submission Sheet

Please use BLOCK CAPITALS

This sheet is provided for your convenience and records.

Please **submit all your marks to us electronically** using the form at
https://www.olympiad.org.uk/2023/bio-mss-2023.html

Please retain all student programs and scripts until 1 February.

Marks that are received after **15 January 2023** will not be considered for the final.

Please fill in details of the school/college and each pupil's name. There is room for 10 entrants in the marks submission table, so duplicate this page if more space is required. It would also be very helpful for us to know what hardware, operating system and programming language(s) each entrant used; please list the different combinations you used in the computer summary table.

School / College: _____ Date exam taken: _____

Name of marker: _____ Date exam marked: _____

Name of Entrant	Marks for each section (maximum in brackets)												Total (100) †	PC/ Lang ‡	School Year §	Age	M/F
	1a (24)	1b (2)	1c (2)	1d (4)	2a (23)	2b (2)	2c (5)	2c (4)	3a (23)	3b (2)	3c (5)	3d (4)					

† Write **N/S** (no submission) in this column if the student produced no answers.

‡ Give the number of the machine and language type in the computer / language type table below

§ Please indicate the type of enumeration used, e.g. year band / curriculum level: _____

Type Number	Hardware e.g. PC / Mac	Processor e.g. Intel Core i7 (2.6 Ghz)	Operating System e.g. Mac OS X 13.0.1	Programming Language e.g. Visual C++
1				
2				
3				
4				