British Informatics Olympiad

CONFIDENTIAL before 31 December 2015

The 2016 British Informatics Olympiad Marking Scheme

Instructions for setting the 2016 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.

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 2016 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
http://www.olympiad.org.uk/2016/2016-result-submission.html

Marks that are received after **31 December 2015** will not be considered for the final.

Certificates will be sent out for all participating students whose marks are returned, including those who submitted no solutions or left early, and for marks that are received before 31 December 2015.

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 2016 exam paper.

Finally, thank you very much for participating in BIO 2016.

Question 1(a) [23 marks available]

For each test of the program for 1(a) you need to type in a single word consisting of uppercase letters. The output should be a vulgar fraction.

[1]	**L**	1 / 2
[1]	**R**	2 / 1
[1]	**LRLL**	4 / 7
[2]	**LLRLR**	5 / 13
[2]	**LLLRRR**	4 / 13
[2]	**LLRRLL**	7 / 17
[2]	**RRRLRRR**	19 / 5
[2]	**LLLLRLLLL**	6 / 29
[2]	**LLLLLLLLLL** (10 Ls)	1 / 11
[2]	**LRLRLRLRLR**	89 / 144

Additional marks are available for general program behaviour:

[2] Program inputs a word.
[2] For each a test a vulgar fraction is output.
[2] Program terminates without crashing / hanging.

Question 1(b) [2 marks available]

[2] LRRR

Question 1(c) [3 marks available]

[2] 999999 Ls
[1] 0 Rs

Question 1(d) [3 marks available]

[1] No

The following pieces of justification are worth at most [2] marks:

[1] A negative fraction has either a negative numerator or denominator.
[1] Two non-negative numbers added together produce a non-negative number.
[1] The formula adds together non-negative numbers, so never produces a negative numerator or denominator.

Question 2(a) [24 marks available]

There are 8 tests used to check program 2(a). For each test you will need to type in 2 lines, the first containing 3 integers and the next containing between 1 and 6 integers.

For each test a 5×5 grid of integers should be output, each integer being a number from 0 to 3.

The entire grid must be correct to receive the marks for that test.

(**Supplementary:** If the student is consistently printing the grids upside-down, mark the grids as though they are in their correct orientation.)

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

Test 1

```
8 1 4
0
```

[2]

```
0 0 1 0 0
0 1 0 1 0
0 0 1 0 0
0 0 0 0 0
0 0 0 0 0
```

Test 2

```
6 3 18
3 5 11
```

[3]

```
1 1 1 1 0
1 1 1 2 1
0 0 1 1 1
1 0 0 1 0
1 1 0 0 1
```

Test 3

```
12 2 7
1 24
```

[3]

```
0 0 0 0 0
0 1 1 0 0
1 1 0 1 0
0 1 1 0 0
0 0 0 0 0
```

Test 4

```
7 3 23
2 9 14
```

[3]

```
0 2 1 2 0
2 1 0 1 2
0 2 2 2 0
0 1 3 1 0
0 0 1 0 0
```

Test 5

```
1 4 61
4 16 4 1

0 1 1 3 3
1 2 0 0 3
1 0 0 0 0
3 0 0 0 3
3 3 0 3 3
```

[3]

Test 6

```
18 5 76
2 2 24 23 4

1 3 3 3 1
3 1 2 1 3
3 2 3 2 3
3 1 3 1 3
1 3 3 3 1
```

[3]

Test 7

```
3 6 150
2 3 5 7 11 13

2 3 2 3 2
3 2 2 2 3
2 2 2 2 2
3 2 2 2 3
2 3 2 3 2
```

[3]

Test 8

```
3 6 999
2 3 5 7 11 13

2 3 2 3 0
2 2 3 2 2
3 2 3 2 1
3 1 1 2 2
0 3 3 1 3
```

[4]

Question 2(b) [2 marks available]

[2] 16

Question 2(c) [4 marks available]

[3] There are 20 possible inputs.

Only a single one of the following (20 options) needs to be given to get [1] mark.

```
1 3 8
2 18 20

1 3 8
7 23 5

6 3 8
2 3 5

6 3 8
22 23 20

3 3 8
3 20 17

3 3 8
8 20 12

3 3 8
13 20 7

3 3 8
18 20 2

3 3 8
23 20 22

8 3 8
3 5 2

8 3 8
8 5 22

8 3 8
13 5 17

8 3 8
18 5 12

8 3 8
23 5 7

11 3 8
17 3 20

11 3 8
22 8 5

16 3 8
12 8 20

16 3 8
17 13 5

21 3 8
7 13 20

21 3 8
12 18 5
```

Question 2(d) [4 marks available]

[1] No.

[1] There are some combinations of starting landscape and position that lead to the same final landscape.

There are [2] marks for either of the following:

[2] If migrations have occurred and at least one person remains on the given position, it is also possible that no migrations occurred and a person was placed in that position.

[2] An explicit example showing two combinations of starting landscape and position that lead to the same final landscape. The position *must* be the same in both.

Question 3(a) [27 marks available]

Each test for 3(a) consists of 3 input integers and an output integer.

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

[1]	`100 2 13`	4
[2]	`20 2 3`	2
[2]	`20 2 13`	4
[2]	`100 73 89`	2
[2]	`100 19 97`	7
[2]	`1000 3 971`	9
[2]	`2000 977 997`	4
[2]	`5000 83 3643`	10
[3]	`614700 3643 90149`	18
[3]	`987654 3643 90149`	16
[3]	`1000000 2 968137`	18
[3]	`1000000 993851 995387`	3

Question 3(b) [2 marks available]

[2] 12

Question 3(c) [3 marks available]

[3] 41041

Question 3(d) [3 marks available]

[3] The shortest path between p and q has a length less than n.

British Informatics Olympiad

2016 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 December 2015.**

Name of Student: Age: School Year:

1(a)

input	`L`	`R`	`LRLL`	`LLRLR`	`LLLRRR`	`LLRRLL`	`RRRLRRR`	`LLLLRLLLL`	`LLLLLLLLL`	`LRLRLRLRLR`
	(1)	*(1)*	*(1)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*
output	1/2	2/1	4/7	5/13	4/13	7/17	19/5	6/29	1/11	89/144

1(b) *LRRR* *(2)*

1(c) *999999 Ls, 0 Rs* *(2+1)*

1(d) *(see marks scheme)* *(3)*

Inputs data? *(2)*
Valid output? *(2)*
Exits okay? *(2)*

TOTAL 1(a) *(23)*

2(a)

input	`8 1 4` / `0`	`6 3 18` / `3 5 11`	`12 2 7` / `1 24`	`7 3 23` / `2 9 14`	`1 4 61` / `4 16 4 1`	`18 5 76` / `2 2 24 23 4`	`3 6 150` / `2 3 5 7 11 13`	`3 6 999` / `2 3 5 7 11 13`
	(2)	*(3)*	*(3)*	*(3)*	*(3)*	*(3)*	*(3)*	*(4)*
output	0 0 1 0 0 0 1 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0	1 1 1 1 0 1 1 1 2 1 0 0 1 1 1 1 0 0 1 0 1 1 0 0 1	0 0 0 0 0 0 1 1 0 0 1 1 0 1 0 0 1 1 0 0 0 0 0 0 0	0 2 1 2 0 2 1 0 1 2 0 2 2 2 0 0 1 3 1 0 0 0 1 0 0	0 1 1 3 3 1 2 0 0 3 1 0 0 0 0 3 0 0 0 3 3 3 0 3 3	1 3 3 3 1 3 1 2 1 3 3 2 3 2 3 3 1 3 1 3 1 3 3 3 1	2 3 2 3 2 3 2 2 2 3 2 2 2 2 2 3 2 2 2 3 2 3 2 3 2	2 3 2 3 0 2 2 3 2 2 3 2 3 2 1 3 1 1 2 2 0 3 3 1 3

2(b) *16* *(2)*

2(c) *20* *(see mark scheme)* *(3+1)*

2(d) *(see mark scheme)* *(4)*

TOTAL 2(a) *(24)*

3(a)

input	`100 2 13`	`20 2 3`	`20 2 13`	`100 73 89`	`100 19 97`	`1000 3 971`
	(1)	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*
output	4	2	4	2	7	9

	`2000 977 997`	`5000 83 3643`	`614700 3643 90149`	`987654 3643 90149`	`1000000 2 968137`	`1000000 993851 995387`
	(2)	*(2)*	*(3)*	*(3)*	*(3)*	*(3)*
	4	10	18	16	18	3

3(b) *12* *(2)*

3(c) *41041* *(3)*

3(d) *(see marks scheme)* *(3)*

TOTAL 3(a) *(27)*

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***
(31)	*(34)*	*(35)*

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2016 British Informatics Olympiad
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
http://www.olympiad.org.uk/2016/2016-result-submission.html

Please retain all student programs and scripts until 1 February.

Marks that are received after **31 December 2015** will not be considered for the final.

Please fill in details of the school/college and each pupil's name as they should appear on certificates. 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 (as it should appear on certificate)	Marks for each section (maximum in brackets)												Total (100) †	PC/ Lang ‡	School Year §	Age	M/F
	1a (23)	1b (2)	1c (3)	1d (3)	2a (24)	2b (2)	2c (4)	2d (4)	3a (27)	3b (2)	3c (3)	3d (3)					

† 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 10.10	Programming Language e.g. Visual C++
1				
2				
3				
4				