The 1999 British Informatics Olympiad

Marking Scheme

CONFIDENTIAL before 14 March 1999

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'99 finalists.

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. Specifically, it does not matter if the output for each test in 3(a) is given in exactly the same order as the answers. Note that if a program does not complete a test in two minutes 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. The script cover sheet is designed to assist you with marking each student's answers. If a script is to be submitted for moderation, this cover sheet should be sent with it. Use the marks submission sheet to list the marks for all your students, including those who submitted no solutions or left early, as this information helps us to assess the level of the exam.

Please send us the marks submission script and any script that scores more than 60 marks. If none of your students scored 60, please send us the best script from your school.

Marks scheme

Question 1(a) **[20 marks available]**

For each test of the program for 1(a) you need to type in a single integer. The response should be a statement containing two integers; there is [1] mark available for each correct integer. There are no marks for incorrect answers.

[2]	**86**	1	101
[2]	**108**	9	117
[2]	**165**	3	204
[2]	**852**	3	1020
[2]	**999**	9	999
[2]	**4759**	1	10003
[2]	**13046**	1	20014

Additional marks are available for general program behaviour.

- [2] Program inputs numbers.
- [2] For each test a statement containing two numbers is output.
- [2] Program terminates without crashing/hanging.

Question 1(b) **[5 marks available]**

[5] 416

(**Supplementary.** The answer 427 is worth [4] marks, and the answer 418 is worth [2].)

Question 2(a) [25 marks available]

There are three multiple part tests used to check program 2(a). Marks are given within the tests, besides the expected output from the program; this will either be a 10 by 10 grid of characters, or a single line of text.

Incorrect output at any stage gets no marks for that stage; for an output grid every character must be correct. If the program crashes/hangs part way through a test, or takes longer than two minutes, the rest of that test should be discarded.

If the program terminates without crashing/hanging at the end of all three tests, an additional [2] marks should be awarded.

Test 1.

```
        4 4
        5 8
        6 4
        6 7
        8 3

        ..........
        ..........
        ....A.....
        .....A....
 [1]    ..........
        ..........
        ...A.A....
        .......A..
        ..........
        ..........

        B 5

        ..........
        ..........
        ....A.....
        .....A....
 [1]    ..........
        ..........
        ...A.A....
        ....+..A..
        ....+.....
        ....+.....

 [1]    Reflected

        R 7

        ..........
        ..........
        ....A.....
        .....*++++
 [1]    ..........
        ..........
        ...A.A....
        .......A..
        ..........
        ..........

 [1]    Absorbed

        B 7

        ..........
        ..........
        ....A.....
        .....A....
 [1]    ..........
        ..........
        ...A.A....
        .......A..
        +++++++...
        ......+...

 [1]    Exits at L 2

        X 0
```

Test 2.

```
        8 2
        3 5
        8 8
        3 8
        8 9

        ..........
        .......A..
        ..A....A..
        ..........
 [1]    ..........
        ..A.......
        ..........
        ..........
        .......A..
        ..........

        T 1

        +.........
        +......A..
        +.A....A..
        +.........
 [1]    +.........
        +.A.......
        +.........
        +.........
        +......A..
        +.........

 [1]    Exits at B 1

        T 4

        ...+......
        ...++++*..
        ..A....A..
        ..........
 [1]    ..........
        ..A.......
        ..........
        ..........
        .......A..
        ..........

 [1]    Absorbed

        L 3

        ..........
        .......A..
        ..A....A..
        ...++++...
 [2]    ...+++++++
        ..A...+...
        ......+...
        +++++++...
        .......A..
        ..........

 [2]    Exits at R 6

        X 0
```

Test 3.

```
        4 2
        6 7
        9 9
        6 2
        9 5

        ..........
        ........A.
        ..........
        .....A....
 [1]    ..........
        ........A.
        ..........
        ..........
        ...A.A....
        ..........

        L 6

        ..........
        ........A.
        ..........
        .....A....
 [1]    +++++.....
        ....+...A.
        ....+.....
        ....+.....
        ...A.A....
        ..........

 [1]    Reflected

        R 3

        ......+...
        ......+.A.
        ......++..
        .....A.+..
 [1]    ......++..
        ......+.A.
        ......+...
        ......++++
        ...A.A....
        ..........

 [1]    Exits at T 7

        R 8

        ..........
        ........A.
        .........+
        .....A...+
 [1]    .........+
        ........A.
        ..........
        ..........
        ...A.A....
        ..........

 [1]    Exits at R 6

        X 0
```

Question 2(b) **[3 marks available]**

[2] 4

An additional [1] mark is available for giving an example. The example should consist of a 10 by 10 array, with a number of atoms marked on it. An example is correct if and only if:

1. Every row of the array either contains an atom, or is touching a row containing an atom.
2. Every column of the array either contains an atom, or is touching a column containing an atom.
3. The number of atoms in the example corresponds to the value given. [Note that a value that scores no marks can still lead to an example that scores marks.]

Question 2(c) **[4 marks available]**

[4] 51

(**Supplementary.** There are several wrong answers which also score marks:
[3] 148 or 50;
[2] 147 or 31;
[1] 106, 105, 30 or 1.)

Question 2(d) **[8 marks available]**

"3 times" case
[1] No (it cannot enter a square exactly 3 times)

[1] If a ray enters a square twice in the same direction, it is [trapped/on an infinite loop], and will enter the square more than three times.
[1] A ray that has entered a square 3 times must have entered from the left & right, or the top & bottom.
[1] A ray that enters a square from the left & right, or top & bottom, must have been reflected.
[1] A reflected ray enters all squares an even number of times.

"4 times" case
[1] Yes (it can enter a square 4 times)

A maximum of [2] marks are available for justification:
[1] A ray can pass through a square twice from deflections.
[1] A ray that passes through a square twice and is then reflected, will pass through the square twice more.
[2] An example illustrating a ray entering a square four times. A typical example is shown at the top of the next column.

Example for 2(d) case 4

```
   A   A
    +++
 A  + +
  +++++
 A  +  A
    +
```

A valid example must show the ray (illustrated above by '+' symbols) bending several times, crossing over itself, and have one end with atoms (shown as 'A') on two adjacent diagonals.

Question 3(a) **[26 marks available]**

There are five tests for 3(a). Tests 2–5 should give more than one line of output; for these tests each output line is marked individually, and the corresponding marks (which are not always equal) are shown. All parts of an output line must be correct for it to receive marks. The output values may be given in any order; for example, in test 2 case 2, an equally valid output would be 4 1x2 1x10 1x5 1x1.

Test 1.

1
1
1
10

[1] 10 10x1

Test 2.

4
1 2 5 10
3
10 18 24

[1] 1 1x10
[1] 4 1x10 1x5 1x2 1x1
[2] 4 2x10 2x2

Test 3.

5
81 9 27 1 3
3
80 50 972

[2] 8 2x27 2x9 2x3 2x1
[2] 6 1x27 2x9 1x3 2x1
[1] 12 12x81

Test 4.

8
2 15 31 83 115 222 223 461
6
60 78 144 170 224 299

[2]	4	4x15
[2]	5	1x2 3x15 1x31
[2]	4	2x15 1x31 1x83
[2]	4	2x2 2x83
[2]	2	1x2 1x222
[2]	4	1x15 2x31 1x222

Test 5.

4
8 13 27 32
2
7 33

[2] Impossible
[2] Impossible

Question 3(b) [4 marks available]

"80" case
[1] 2 rounds
[1] Romulus: 81, Remus: 1

"50" case
[1] 4 rounds
[1] Romulus: 81 Remus: 1, 3, 27 OR
Romulus: 27, 27 Remus: 3, 1

(**Supplementary.** Students who mix up Romulus and Remus should lose no marks.)

Question 3(c) [5 marks available]

[5] 1333

End of BIO'99 marks scheme

DATA CONNECTION

The 1999 British Informatics Olympiad

Script cover sheet

British Informatics Olympiad

Please use this sheet, with reference to the marks scheme, to assist you with marking each student's script. This cover sheet should accompany all scripts submitted to the BIO organisers. As it summarises the solutions to many questions, **do not distribute or show this sheet to any contestant before 14 March 1999.**

Name of student: ______________________________ Age: ___________ Year in school: _________

Input:	86	108	165	852	999	4759	13046	*Inputs no.s?*	*Outputs 2 no.s?*	*Exits OK?*
1 (a)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Output:	1 101	9 117	3 204	3 1020	9 999	1 10003	1 20014			

Totals for Q1: **1 (a)** (20) **1 (b)** (5)

1 (b) *Answer* 416 *gets* (5) *marks or* 427 (4) *marks or* 418 (2) *marks*

Comments:

2 (a) Test 1

Input: 4 4 / 5 8 / 6 4 / 6 7 / 8 3

	(initial)	B 5		R 7		B 7	X 0
2 (a)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Test 1	*Initial state*	*Shows ray reflected*	Reflected	*Shows ray absorbed*	Absorbed	*Shows deflection*	Exits at L 2

2 (a) Test 2

Input: 8 2 / 3 5 / 8 8 / 3 8 / 8 9

	(initial)	T 1		T 4		L 3	X 0
2 (a)	(1)	(1)	(1)	(1)	(1)	(2)	(2)
Test 2	*Initial state*	*Straight through*	Exits at B 1	*Deflects/ absorbed*	Absorbed	*Deflected 4 times*	Exits at R 6

2 (a) Test 3

Input: 4 2 / 6 7 / 9 9 / 6 2 / 9 5

	(initial)	L 6		R 3		R 8		X 0
2 (a)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(2)
Test 3	*Initial state*	*Deflected/ reflected*	Reflected	*Deflected 5 times*	Exits at T 7	*Deflected at edge*	Exits at R 6	

Totals for Q2: **2 (a)** (25) **2 (b)** (3)

For **2(b)** *answer* 4 *gets* (2) *marks, plus* (1) *for giving an example*

2 (c) (5)

51 *gets* (5) – *see marks scheme for other answers*

See marks scheme for answers to **2(d)**

2 (d) (8)

Comments:

Tests 1–5 Input	1 1 1 10	4 1 2 5 10 3 10 18 24	5 81 9 27 1 3 3 80 50 972	8 2 15 31 83 115 222 223 461 6 60 78 144 170 224 299	4 8 13 27 32 2 7 33
3 (a)	(1)	(4)	(5)	(12)	(4)
(mark) *Output*	(1) 10 10x1	(1) 1 1x10 (1) 4 1x10 1x5 1x2 1x1 (2) 4 2x10 2x2	(2) 8 2x27 2x9 2x3 2x1 (2) 6 1x27 2x9 1x3 2x1 (1) 12 12x81	(2) 4 4x15 (2) 5 1x2 3x15 1x31 (2) 4 2x15 1x31 1x83 (2) 4 2x2 2x83 (2) 2 1x2 1x222 (2) 4 1x15 2x31 1x222	(2) Impossible (2) Impossible

3 (a) Total (26)

3 (b)

"80" case (2)

(1) 2 rounds
(1) Romulus: 81, Remus: 1

"50" case (2)

(1) 4 rounds
(1) Romulus: 81 Remus: 1, 3, 27 OR
Romulus: 27, 27 Remus: 3, 1

3 (b) (4) **3 (c)** (5)

1333

Comments:

Marked by ____________

Total mark for BIO'99 (100)

Send to: Antony Rix, British Informatics Olympiad, Christ's College, Cambridge CB2 3BU Fax: 01223 334 967

DATA CONNECTION

The 1999 British Informatics Olympiad

Marks submission sheet

British Informatics Olympiad

Please fill in details of the school/college and each pupil's name as they should appear on certificates (if applicable). There is room for 8 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.

Make a copy of the completed forms before sending them, and enclose cover sheets, scripts, printouts and disks (labelled with type e.g. PC 1.4MB) from your highest-scoring student, and all others who score over 60 marks.

School/College: ____ Date exam taken: ____________

Name of marker: ____ Date exam marked: ____________
(in BLOCK CAPITALS)

Marks submission table.

BIO'99 Name of entrant (this will appear on certificate if appropriate)	Marks for each section (maximum in brackets)									Total mark (100) *note 1*	PC/Lang. type *note 2*	Age in years	Year in school *note 3*
	1a (20)	1b (5)	2a (25)	2b (3)	2c (4)	2d (8)	3a (26)	3b (4)	3d (5)				

Note 1 Write N/S (no submission) in this column if the student produced no answers.
Note 2 Give the number of the machine and language type in the computer/language type table below.
Note 3 Please use National Curriculum year bands: year 11 (age 15-16, 5th form, GCSE year), 12 for lower VIth, 13 for upper VIth, etc.

Computer summary table.

Type number	Hardware *e.g. PC/Mac/Arc*	Processor *e.g. P150*	Operating system *e.g. Win95*	Programming language(s) *e.g. Turbo Pascal*
1				
2				
3				
4				

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