BIO'96

The 1996 British Informatics Olympiad
Round One

Marking Scheme

CONFIDENTIAL

The three questions on this paper are split into a total of 9 parts. Questions 1(a), 2(a) and 3(a) are to be marked using the competitors' programs, and the remaining questions purely from their written answers. Programs written by the competitors to help in the written questions may be used by the BIO committee when selecting the finalists.

For each competitor you should have a set of programs and a written paper. The program names used by competitors should be clearly marked on their written 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.

The first part of each question is to be 'black-box' tested. In other words you will be required to run the program, enter the given data and verify the solution. For each test the data to be entered will be given in **`bold text`**. Flexibility is allowed in the output format (there is no penalty for extra spaces etc.), but the solutions must be correct for marks to be scored. Note that if any program has not completed a test in two minutes of processing time, it is to be treated as if it has failed that test.

The written questions have specific answers, though 2(b) and 3(b) require a reasoned argument. Partial answers which are working towards the given solution may be given partial marks, but answers not covered under the mark scheme should get no marks.

All marks are given in square brackets by the test/answer they relate to. In some cases details are given on how marks may be split up, as well as alternative answers which merit points.

Question 1(a) [20 marks available]

The following pairs of numbers should be used to test the program for 1(a). The correct response is given to the right of each pair. There are no marks for incorrect answers.

[2]	**2620, 2924**	`Amicable`
[4]	**6368, 6232**	`Amicable`
[2]	**932, 1023**	`Not Amicable`
[2]	**1996, 1504**	`Not Amicable`
[2]	**496, 496**	`Not Amicable`

Additional marks are available for general program behaviour.

[3] Program inputs two numbers
[3] For each pair of numbers either "Amicable" or "Not Amicable" is printed.
[2] Program terminates without crashing/hanging.

Question 1(b) [3 marks available]

[3] 220, 284

(Supplementary: if the answer given is 6, 6 and the pair 496, 496 was believed to be amicable in 1(a), then [2] marks should be given.)

Question 2(a) [25 marks available]

There are two multiple part tests used to check program 2(a). Marks are given within the tests, besides the expected output from the program. Comments are given on the right-hand side, indicating why the marks are being given. Incorrect output at any stage gets no marks for that stage. If the program crashes/hangs part way through a test, or takes longer than two minutes, the rest of that test should be discarded.

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Test 1 *Program text* Comments

```
.....
..0..
.000.
.....
.....
```

Starting state

[2]

```
...........
...........
...........
...........
.....0.....
....000....
...........
...........
...........
...........
...........
```

Printing generation 0

[8]

```
#1
...........
...........
...........
...........
....000....
....000....
.....0.....
...........
...........
...........
...........
```

Advancing a generation, and understanding #n

[3]

```
+1
...........
...........
...........
.....0.....
....0.0....
...........
....000....
...........
...........
...........
...........

-1
```

Understanding +n

[1] Mark for program terminating cleanly.

(Supplementary: if the output after #1 was either a repetition of generation 0 or blank, and the output after +1 is the output expected after #1 then score 4/8 and 0/3 for those parts respectively. Furthermore in test 2 replace #9 by +9)

Test 2 *Program text* Comments

```
00000
00000
00.00
00000
00000
```

[2]

```
...........
...........
...........
...00000...
...00000...
...00.00...
...00000...
...00000...
...........
...........
...........
```

Printing generation 0

[8]

```
#9
....000....
...0...0...
...........
.0.......0.
0.........0
0.........0
0.........0
.0.......0.
...........
...0...0...
....000....

-1
```

See supplementary comment for test 1

Border conditions correct

[1] Mark for program terminating cleanly.

Question 2(b) [4 marks available]

There are three key points worth marks. The second two are justified by the first, but merit marks on their own.

[1] Several different boards might have identical future generations.

[1] There might not be a unique preceding generation.

[1] There might not be any preceding generation.

Additionally,

[1] An example of any of the above three points.

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

[3] 512×512
or 262,144

While this answer on its own is worth all the marks, in the event of an incorrect answer there are marks for saying:

[1] There are 512 birth rules.
[1] There are 512 survival/death rules.

(Supplementary: The rule set definition allows for survival and birth with 0 'on' neighbours. Similarly it does not restrict survival and birth to just intervals. Making such assumptions leads to different results. Up to [2] marks can be given in total for these alternatives:

[1] 46 births (only intervals, including zero conditions)
[1] 37 births (only intervals, excluding zero conditions)
[1] 256 births (excluding zero conditions)
[1] 46 survival/death (only intervals)

There are no marks available for excluding the 0 condition from survival/death.)

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

[8] 1426

(Supplementary: 1408 scores [6] marks. If intervals were assumed in the previous part both 189 and 191 are also worth [6] marks.)

Question 3(a) **[25 marks available]**

The following tests have multiple solutions. The given answers just show the positions of the fixed doubles; note they can have any value, so they are just shown as `D-D` on the solutions. Marks should be given if the solution appears valid, ie.

1) Check the fixed doubles are correct.
2) Check all 7 doubles present.
3) Do a few spot checks to ensure touching squares (in orthogonal directions) are only identical if they belong to the same domino.

Test 1 *Program text*

[5]

```
-1

. . . . . . . .

. . . . . . . .

. . . . . . . .

. . . . . . . .

. . . . . . . .

. . . . . . . .

. . . . . . . .
```

Test 2 *Program text*

[5]

```
8 3 B
4 1 R
5 7 R
-1

. . . D-D . . .

. . . . . . . .

. . . . . . . D
              |
. . . . . . . D

. . . . . . . .

. . . . . . . .

. . . . D-D . .
```

Test 3 *Program text*

[5]

```
2 1 B
4 5 R
3 3 R
7 2 R
7 3 B
1 7 R
3 7 R
-1

. D . . . . . .
  |
. D . . . . D-D

. . D-D . . D .
            |
. . . . . . D .

. . . D-D . . .

. . . . . . . .

D-D D-D . . . .
```

The following four test cases should all produce the word "Impossible".

Test 4 *Program text* Comments

```
8 1 R
-1

Impossible
```

[1] Domino over the edge of the board

Test 5 *Program text*

```
3 4 R
4 3 B
-1

Impossible
```

[1] Dominoes overlapping

Test 6 *Program text*

```
6 7 R
8 5 B
-1

Impossible
```

[3] Isolated square

Test 7 *Program text*

```
3 6 r
4 5 r
4 7 r
7 7 r
-1

Impossible
```

[5]

Question 3(b) **[4 marks available]**

[4] Any permutation of the numbers 0-6 leads to another valid solution.

(Reflections and rotations cannot guarantee other solutions, since they may break the double restrictions.)

Question 3(c) **[8 marks available]**

[8] $1{,}292{,}697 \times 28! \times 2^{21}$
or $1{,}292{,}697 \times 28! \times 2{,}097{,}152$

Expressing the answer above, with any part written approximately ($28! \approx 3.049\times10^{29}$) or an approximate answer (8.265×10^{41}) is worth [7] marks. In the event of an incomplete, or incorrect answer there are marks for:

[4] 1,292,697 distinct tessellations.
[1] 28! ways of choosing the dominoes for each tessellation.
[2] 2^{21} ways of placing the 21 ordered non-double pieces.

End of BIO'96 Round One Marks Scheme

DATA CONNECTION

BIO’96

The 1996 British Informatics Olympiad
Round One
Marks submission sheet

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 12 entrants, so duplicate this page if more space is required. Make a copy of the completed forms before sending them, and enclose scripts, printouts and disks (labelled with type eg. PC 1.4MB) from all pupils who score over 70 marks.

School/College

Name of marker

BIO’96 Round One Name of entrant	Age years	Marks for each section (maximum)									Total mark (100)
		1a (20)	1b (3)	2a (25)	2b (4)	2c (3)	2d (8)	3a (25)	3b (4)	3c (8)	

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Date exam was taken:

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