The 1997 British Informatics Olympiad
Marking Scheme

The three questions on this paper are split into a total of 10 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 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(c) and 3(c) 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.

Accompanying this marks scheme are two marking 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.

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

The following pairs of numbers (representing times) should be used to test the program for 1(a). The correct response is given to the right of each pair. Marks should not be deducted for incorrect spelling, but an incorrect time or failing to use the correct format (e.g. using "fifteen minutes past" and not "quarter past") gets no marks.

[2]	**`1 0`**	`One o'clock`
[2]	**`2 15`**	`Quarter past two`
[2]	**`3 30`**	`Half past three`
[2]	**`3 45`**	`Quarter to four`
[2]	**`10 11`**	`Eleven minutes past ten`
[2]	**`11 38`**	`Twenty-two minutes to twelve`
[2]	**`12 44`**	`Sixteen minutes to one`

Additional marks are available for general program behaviour:

- [2] Program inputs two numbers.
- [2] For each pair of numbers a time is printed. Note that this need not be the correct time, or correctly formatted.
- [2] Program terminates without crashing/hanging.

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… Question 1 *continued from previous page*

Question 1(b) [5 marks available]

The correct times are
11:23 11:27 11:28 12:23 12:27 12:28.

These can be given numerically or in words.

Marks should be awarded as follows:

[5] All correct times are listed. No invalid times are listed.

[4] At least half the correct times are shown. No invalid times are listed.

[3] At least one, but fewer than half of the correct times are listed. No invalid times are listed.

[2] At least two correct times are listed, but invalid times are also listed.

[1] One correct time is shown along with at least one invalid time.

(**Supplementary**: If the answers to the 11:38 and 12:44 tests in 1(a) were printed as "Thirty-eight minutes past eleven" and "Forty-four minutes past twelve" the following times count as correct - 11:23, 11:27, 11:28, 11:33, 11:37, 11:38, 12:23, 12:27, 12:28, 12:33, 12:37 and 12:38 and marks should be awarded based on these.)

Question 2(a) [25 marks available]

There are two multiple part tests used to check 2(a). Marks are given within the tests, to the left of 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.

… Question 2 (a) *continued from previous column*

Note: Test 2 will produce different output depending on which strategy has been implemented, although the input will remain the same. There are more marks available for implementing the second strategy. The strategy implemented should be displayed after the initial data has been input, and you should follow the marking scheme indicated for this strategy.

Test 1 (both strategies)

Test 1	*Program text*	Comments
	.... .*0. .0*.	
[1]	Strategy 1 (or 2)	Printing strategy
[1]	....*0... ...0*...	Displaying initial board
	0 3 5	
[2]	....000... ...0*...	Playing a correct white move
	0 3 6	
[2]	....*..... ..0*0... ...0*...	Playing a correct black move
	-1	

[1] Mark for program terminating cleanly.

continued on next page…

… Question 2 (a) *continued from previous page*

Test 2 (Strategy 1)

Test 2 (Strategy 1) | *Program text* | Comments

```
0.0*
0000
0*00
..0*

Strategy 1
........
........
..0.0*..
..0000..
..0*00..
....0*..
........
........

1
```

[2] Playing first move

```
........
........
..0.0*..
..0000..
..0*00..
....00..
......0.
........

1
```

[2] Playing second move

```
........
........
..0.0*..
..000*..
..0*0*..
....**..
.....*0.
........

10
```

[2] Playing 10 moves ahead

```
.....0*.
.....0..
..0.*0..
..0*0*..
0000***.
....0**.
.....**.
.....***

39
```

[2] Playing to the end of the game

```
*0000000
0*****0*
00***0**
000***0*
0000****
00000***
0000****
00000***
```

[2] Printing the correct conclusion

```
White wins by
4.
```

Test 2 (Strategy 2)

Test 2 (Strategy 2) | *Program text* | Comments

```
0.0*
0000
0*00
..0*

Strategy 2
........
........
..0.0*..
..0000..
..0*00..
....0*..
........
........

1
```

[3] Playing first move

```
........
........
..0.0*..
..0000..
..0000..
..0.0*..
........
........

1
```

[3] Playing second move

```
........
........
..0.0*..
..00*0..
..0*00..
..*.0*..
.*......
........

10
```

[5] Playing 10 moves ahead

```
........
.*0.....
..0.0*..
..0**0..
..00**..
..0.***.
.00.**..
0...000.

39
```

[5] Playing to the end of the game

```
***0****
0*000**0
0000*0*0
0000**00
00000**0
00000*00
0000**00
00000000
```

[2] Printing the correct conclusion

```
White wins by
26.
```

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… Question 2 (a) *continued from previous page*

(**Supplementary 1 (both strategies)**: A program may play according to one of the strategies but fail to print which strategy it is using, or incorrectly print the strategy. In these cases mark using the scheme that most closely matches the program's output, but debit [1] mark.)

(**Supplementary 2 (both strategies)**: If the final board position is incorrect, but the conclusion given is correct for the board position output, then the [2] marks for the conclusion should be given.)

Question 2(b) [2 marks available]

[2] 19

Question 2(c) [5 marks available]

[1] Yes (there is a strategy).

Additionally, up to four additional marks can be gained from the following points:

[1] If White plays onto a square neighbouring an empty corner then Black can take that corner next move.

[1] If White avoids the neighbouring squares for as long as possible, and so does Black, we will get a board where only the corner squares and their neighbours are empty.

[1] There are an even number of empty squares to start with, excluding the corner squares and their neighbours.

[1] An even number of empty squares means it's White turn to play.

[1] If only the corners and their neighbouring squares are free, then it is White's turn to play.

[1] Black can force White to be the first to play in one of the squares neighbouring a corner.

Question 2(d) [8 marks available]

[8] 8037

(**Supplementary**: 7759 scores [5] marks)

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Question 3(a) [23 marks available]

All ten tests in this section have multiple solutions. For each test only the optimal solutions are given. For the first seven tests, the program gets two marks for finding these optimal solutions and one mark for a non-optimal solution. (Examples of likely non-optimal solutions to Tests 5, 6 and 7 are given in brackets.)

If alternative solutions are produced they should be checked by calculator. A solution to the input "a b" is valid if a/b is equal to the sum of the reciprocals of the numbers output. Additionally, the numbers output must all be different, and should have no more than 8 digits.

Mark tests 1-7 as follows:

[2] If the answer given is one of the optimal solutions.
[1] If the answer given is valid but not optimal.

[2]	Test 1:	**1 20**	`20`
[2]	Test 2:	**36 612**	`17`
[2]	Test 3:	**2 15**	`12 20`
[2]	Test 4:	**2 37**	`19 703`
[2]	Test 5:	**27 441**	`28 49 196` `(17 417 347361)`
[2]	Test 6:	**4 109**	`30 545 654` `(28 1018 1553468)`

[2]	Test 7:	**59 211**	`4 36 633 3798`
			`6 9 633 3798`
			`(4 34 4783 68626484)`

For the final three tests **any valid solution** scores all [3] marks. An additional non-optimal solution is given for test 8, and test 10 has four equally valid optimal solutions. If other output is produced, use a calculator to check that it is a valid solution to within rounding error.

… Question 3 (a) *continued from previous column*

[3]	Test 8:	**101 103**	`2 3 7 238 5253` `(2 3 7 228 164388)`
[3]	Test 9:	**907 911**	`2 4 5 22 10021 18220`

[3]	Test 10:	**523 547**	`2 3 9 90 2735 4923`
			`2 3 10 45 2735 4923`
			`2 3 15 18 2735 4923`
			`2 4 5 180 2735 4923`

Question 3(b) [2 marks available]

[1] Part (i) 1/7

[1] Part (ii) 31/32

Question 3(c) [5 marks available]

A total of five marks may be obtained by making the following points.

[1] No.

[1] All fractions (b/c) can be written as an Egyptian fraction.

[1] Every unit fraction can be written as an Egyptian fraction with more than one term.

[2] If we have an Egyptian fraction we can make an equivalent Egyptian fraction by expanding its smallest unit fraction into an Egyptian fraction of more than one term.

Question 3(d) [5 marks available]

[5] 303791

(**Supplementary**: 304191 scores [4] marks)

End of BIO'97 Marks Scheme

The 1997 British Informatics Olympiad

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 10 entrants, so duplicate this page if more space is required. 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)

BIO'97	Marks for each section (maximum in brackets)										Total	Age in	Year
Name of entrant (this will appear on certificate if appropriate)	1a (20)	1b (5)	2a (25/17)	2b (2)	2c (5)	2d (8)	3a (23)	3b (2)	3c (5)	3d (5)	mark* (100)	years	in+ school

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

\+ Please use National Curriculum year bands.
For example give '11' for year 11 (age 15-16, 5th form, GCSE year), '12' for Lower VIth, '13' for Upper VIth.

Send to: Antony Rix
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The 1997 British Informatics Olympiad

Script cover sheet

Please use this sheet to assist you with marking each student's script. This cover sheet should accompany all scripts submitted to the BIO organisers.

The maximum mark available for each part is given in brackets.

Name of student: ______________________ Age: ________ Year in school: ________

Question 1

	Tests							Additional marks		
1 (a)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)

1 (a) Total	**1 (b)**
(20)	(5)

Comments:

Question 2

2 (a)					
Test 1 (both strategies)	(1)	(1)	(2)	(2)	(1)
Test 2 (strategy 1)	(2)	(2)	(2)	(2)	(2)
Test 2 (strategy 2)	(3)	(3)	(5)	(5)	(2)

2 (a) Total
(25)

(Maximum of 17 marks for strategy 1)

2 (b)	**2 (c)**	**2 (d)**
(2)	(5)	(8)

Comments:

Question 3

	Tests 1-7. Award [2] for optimal sol^n, [1] for valid, non-optimal sol^n.							Tests 8-10. Award [3] for any valid sol^n		
	1	2	3	4	5	6	7	8	9	10
3 (a)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(3)	(3)	(3)

3 (a) Total
(23)

3 (b)	**3 (c)**	**3 (d)**
(2)	(5)	(5)

Comments:

Total

Total mark for BIO'97
(100)

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