The 1998 British Informatics Olympiad
Marking Scheme

CONFIDENTIAL before 15 March 1998

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'98 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 2(a) and 3(a) is not split across lines in exactly the same way 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.

Question 1(a) [20 marks available]

The following numbers should be used to test the program for 1(a). The correct response is given next to each number (lower case is also acceptable). There are no marks for incorrect answers.

Mark	*Number*	*Correct solution*
[2]	**`5`**	`V`
[2]	**`13`**	`XIII`
[2]	**`99`**	`XCIX`
[2]	**`444`**	`CDXLIV`
[2]	**`720`**	`DCCXX`
[2]	**`2803`**	`MMDCCCIII`
[2]	**`3888`**	`MMMDCCCLXXXVIII`

Additional marks are available for general program behaviour:

[2] Program inputs numbers
[2] For every number a Roman numeral (not necessarily correct) is output.
[2] Program terminates without crashing/hanging.

Question 1(b) [4 marks available]

[2] CI
[2] MDCCCLXIV

(**Supplementary for 1(b).** If these answers are not given in Roman numerals, rather as 101 and 1864, [1] mark is available for each correct answer.)

Question 1(c) [6 marks available]

[3] 55 Roman numerals are shorter.
[3] 3800 Roman numerals are longer.

(**Supplementary for 1(c).** If the second answer is given as 3799, [2] marks should be awarded.)

Question 2(a) [24 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.

(**Supplementary for 2(a) tests 1 and 2.** If the `'F'` and `'P'` have their location swapped throughout both tests, only the first [2] marks on test 1 should be deducted.)

continued…

2(a) Test 1 [13 marks available]

Mark **Program text** **Explanation**

```
3 3
3 5
```

[2] *Printing out initial position (see supplementary)*

```
..........
..........
..........
..........
..........
..F.......
..........
..P.......
..........
..........

M 1
```

[2] *Moving correctly*

```
..........
..........
..........
..........
..F.......
..........
..P.......
..........
..........
..........

T 2
3 8
4 7
```

[2] *Placing obstacles correctly*

```
..........
..........
..*.......
...*......
..F.......
..........
..P.......
..........
..........
..........

M 3
```

[2] *Printing when Farmer & pigs meet*

```
Farmer and pigs meet
on move 4 at (3,7)
```

[1] *Correctly printing a '+'*

```
..........
..........
..*.......
..+*......
..........
..........
..........
..........
..........
..........

M 25
```

[3] *Boundary conditions*

```
...P.F....
..........
..*.......
...*......
..........
..........
..........
..........
..........
..........

X
```

[1] Mark for program terminating cleanly.

2(a) Test 2 [11 marks available]

Mark **Program text** **Explanation**

```
3 6
1 5
```

[1] *Printing out initial condition*

```
..........
..........
..........
..........
..P.......
F.........
..........
..........
..........
..........

T 4
1 8
7 10
10 3
3 1
```

[2] *Placing obstacles correctly on boundary*

```
......*...
..........
*.........
..........
..P.......
F.........
..........
.........*
..........
..*.......

M 55
```

[1] *Printing when farmer & pigs meet*

```
Farmer and pigs meet
on move 51 at (4,4)
```

[2] *Printing the board position after move 55, not when the farmer & pigs meet*

```
......*...
..........
*..P......
..........
..........
..........
F.........
.........*
..........
..*.......

M 300
```

[2] *Printing several farmer & pig meetings* ([2] *marks should be given only if all three meetings are correctly listed*)

```
Farmer and pigs meet
on move 64 at (6,7)
Farmer and pigs meet
on move 301 at (6,4)
Farmer and pigs meet
on move 314 at (4,7)
```

[2] *Making a large number of moves*

```
......*...
..........
*.........
..........
..........
..........
.......F..
.........*
.....P....
..*.......

X
```

[1] Mark for program terminating cleanly.

continued…

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

[1] Minimum 1
[1] Maximum 81

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

[3] 19

A solution, which does not need to be given by the contestants, is to start at (1,1) and (2,1) with pigs and farmer both facing up.

Question 2(d) **[5 marks available]**

[1] Yes, we can always determine whether the farmer and pigs will meet.

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

[1] If the farmer and pigs will meet, we will know this when the simulation reaches this position.
[1] If we return to a state (configuration / setup / position) that we have seen before, all future states will be repetitions of ones we have seen before.
[1] Once we have simulated all the possible states we will know if the farmer and pigs will ever meet.
[1] The simulation only has a finite number of states.
[1] We must eventually repeat a state we have previously seen.

Question 3(a) **[24 marks available]**

The program for part 3(a) is to be marked with six tests.

In tests 1 and 2 the alphametics have multiple solutions. All valid solutions are listed, sorted by total; a program need only give one solution. [4] marks are to be given for any correct solution, but [2] of those marks should be deducted if the program also prints 'Unique'.

Test 1: [4]

```
3
ONE
ONE
TWO
206 + 206 = 412
216 + 216 = 432
231 + 231 = 462
236 + 236 = 472
271 + 271 = 542
281 + 281 = 562
286 + 286 = 572
291 + 291 = 582
407 + 407 = 814
417 + 417 = 834
427 + 427 = 854
432 + 432 = 864
452 + 452 = 904
457 + 457 = 914
467 + 467 = 934
482 + 482 = 964
```

Test 2: [4]

```
3
FATHER
MOTHER
PARENT
186753 + 296753 = 483506
286753 + 196753 = 483506
```

Tests 3 and 4 have unique solutions. For each test [4] marks should be given for printing the correct solution and the word 'Unique'. If the word 'Unique' is absent, only [2] marks should be given for the correct solution.

Test 3: [4]

```
4
SEVEN
SEVEN
SIX
TWENTY
68782 + 68782 + 650 =
 138214
Unique
```

Test 4: [4]

```
6
THREE
THREE
TWO
TWO
ONE
ELEVEN
84611 + 84611 + 803 +
 803 + 391 = 171219
Unique
```

Tests 5 and 6 have no solutions. For each test [4] marks should be given for printing the word 'Impossible', and [0] marks are available for any other output.

Test 5: [4]

```
3
BIO
FIRST
ROUND
Impossible
```

Test 6: [4]

```
5
SEVENTEEN
SEVENTEEN
SEVENTEEN
SEVENTEEN
SIXTYEIGHT
Impossible
```

(N.B. Test 5 is **not** the same as the example alphametic in question 3(b).)

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

There are 16 different solutions, listed below and sorted by total. Score [2] marks for a single correct solution, and [4] marks for two correct solutions. Additional correct solutions, and any incorrect solutions, should be ignored.

```
509 + 19638 = 20147     509 + 39817 = 40326
609 + 19538 = 20147     809 + 39517 = 40326
309 + 19847 = 20156     509 + 39862 = 40371
809 + 19347 = 20156     809 + 39562 = 40371
309 + 19865 = 20174     709 + 59814 = 60523
809 + 19365 = 20174     809 + 59714 = 60523
509 + 19674 = 20183     709 + 59832 = 60541
609 + 19574 = 20183     809 + 59732 = 60541
```

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

[1] Yes
[2] Any valid example. [1] mark for giving the alphametic (using only one letter), and [1] mark for giving its numeric solution. For example A+A+A+A+A+A+A+A+A+A+A = AA has a solution with A equal to 1,2,3,4,5,6,7,8 or 9.

Question 3(d) **[5 marks available]**

[2] There are 163 valid alphametics/letter combinations
[3] 1136 different sums can be represented.

End of BIO'98 marks scheme

DATA CONNECTION

The 1998 British Informatics Olympiad

Script cover sheet

BIO'98

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 15 March 1998.**

Name of student: ____________________________ Age: __________ Year in school: ________

Question 1

Input:	`5`	`13`	`99`	`444`	`720`	`2803`	`3888`	*Inputs no.s?*	*Outputs Roman?*	*Closes OK?*
1 (a)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)

Totals for Q1

1 (a)	**1 (b)**	**1 (c)**
(20)	(4)	(6)

1(b)	(2)	(2)	**1 (c)**	(3)	(3)
answers:	CI	MDCCCLXIV	*answers:*	55	3800

Comments:

Question 2

Input:	`3 3`
	`3 5`
		`M 1`	`T 2`
			`3 8`
			`4 7`
				`M 3`		`M 25`	`X`

2 (a)	(2)	(2)	(2)	(2)	(1)	(3)	(1)
Test 1	*Initial position (see sup.)*	*Moves correctly*	*Places trees*	*Meet on move 4 at (3,7)*	*Displays '+'*	*Boundary conditions*	*Terminates cleanly*

Input:	`3 6`
	`1 5`
		`T 4`
		`1 8`
		`7 10`
		`10 3`
		`3 1`
			`M 55`		`M 300`		`X`

2 (a)	(1)	(2)	(1)	(2)	(2)	(2)	(1)
Test 2	*Initial position*	*Places trees*	*Meet move 51 at (4,4)*	*Displays board 55*	*Three meetings*	*Large no. of moves*	*Terminates cleanly*

2 (b)	
(1)	(1)
1	81

2 (a) Total (24)

2 (b) Total (2)

2 (c)	**2 (d)**
(3)	(5)
19	*(see mark scheme)*

Comments:

Question 3

Input:	`3`
	`ONE`
	`ONE`
	`TWO`
		`3`
		`FATHER`
		`MOTHER`
		`PARENT`
			`4`
			`SEVEN`
			`SEVEN`
			`SIX`
			`TWENTY`
				`6`
				`THREE`
				`THREE`
				`TWO`
				`TWO`
				`ONE`
				`ELEVEN`
					`3`
					`BIO`
					`FIRST`
					`ROUND`
						`5`
						`SEVENTEEN`
						`SEVENTEEN`
						`SEVENTEEN`
						`SEVENTEEN`
						`SIXTYEIGHT`

3 (a)	(4)	(4)	(4)	(4)	(4)	(4)

Sol'n	*(see marks scheme as there are 16 valid solutions and only one is required)*	`186753 +`
		`296753 =`
		`483506` *or*
		`286753 +`
		`196753 =`
		`483506`
			`68782 +`
			`68782 +`
			`650 =`
			`138214`
			`Unique`
				`84611 +`
				`84611 +`
				`803 + 803`
				`+ 391 =`
				`171219`
				`Unique`
					`Impossible`	`Impossible`

3 (a) Total (24)

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

(see marks scheme for solutions to these parts)

Comments:

Marked by

Total mark for BIO'98 (100)

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

DATA CONNECTION

BIO'98

The 1998 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 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'98 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 (4)	1c (6)	2a (24)	2b (2)	2c (3)	2d (5)	3a (24)	3b (4)	3c (3)	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. P90*	Operating system *e.g. Win95*	Programming language(s) *e.g. Turbo Pascal*
1				
2				
3				
4				

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