British Informatics Olympiad

CONFIDENTIAL before 15 January 2020

The 2020 British Informatics Olympiad Marking Scheme

Instructions for setting the 2020 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 2020 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/2020/submission-record-2020.html

Marks that are received after **15 January 2020** 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 1 February 2020.

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 2020 exam paper.

Finally, thank you very much for participating in BIO 2020.

Question 1(a) [25 marks available]

For each test of the program for 1(a) you need to type in a Roman numeral followed by an integer. The output should be a pair of integers both of which are required to match exactly.

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

[1]	**MMXX 3**	6 2
[1]	**C 1**	1 0
[2]	**V 1**	1 1
[2]	**III 2**	2 1
[2]	**I 7**	6 2
[2]	**MMXX 8**	30 12
[2]	**II 20**	101 37
[2]	**IV 20**	121 46
[2]	**MDCLX 30**	1795 695
[2]	**M 50**	2858 1103
[2]	**V 50**	2858 1104
[2]	**MMDCCCLXXXVIII 50**	19013 7333

Additional marks are available for general program behaviour:

[1] Program inputs a Roman numeral and an integer.
[1] For each a test two integers are output.
[1] All tests terminate without without crashing / hanging.

Question 1(b) [2 marks available]

[1] 4
[1] II, III, IV, IX

(**Supplementary:** If a number lower than 4 is given and the corresponding examples are all from the list, score [1] mark)

Question 1(c) [4 marks available]

[4] 3919

Question 2(a) [24 marks available]

There are 9 tests used to check 2(a). For each test you will need to type a word consisting of *uppercase* letters, followed by two integers.

For each test you should see several lines of uppercase letters. All but the last line should be treated as a single block, and every line in the block needs to match (without additional or omitted letters) to score. Letters on each line *should* be in alphabetical order, however a student whose letters are not alphabetical order can still be awarded the marks.

The last line is graded separately and both letters on this line are required to match and must be in the order given on this mark scheme. A blank line has been added before the last line for clarity below – this will *not* be present in student output.

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

Test 1 **A 1 2**

```
BC
A
```
[1] A

[1] BA

Test 2 **C 4 8**

```
C
C
```
[1] AB

[1] BB

Test 3 **BC 4 9**

```
B
AC
```
[1] BD
```
C
```

[1] CD

Test 4 **BBACC 10 1010**

```
BC
ADE
```
[1] AFG
```
B
B
C
C
```

[2] FG

Test 5 **ABCD 50 51**

```
BE
AC
BD
CF
A
D
```
[1]

```
CD
```
[2]

Test 6 **FEDC 2020 876543**

```
F
E
DF
CE
BD
AC
```
[1]

```
CB
```
[2]

Test 7 **AABGB 5000 9999**

```
BCD
AFG
A
A
G
B
BE
```
[1]

```
AB
```
[2]

Test 8 **CDCDCD 2020 876543**

```
C
D
ADEG
BCFH
C
D
C
D
```
[1]

```
DH
```
[2]

Test 9 **FFFFFFFF 512 1022**

```
F
F
F
F
F
ABCDEGHIJ
F
F
F
F
```
[1]

```
JA
```
[2]

Question 2(b) [2 marks available]

[1] A
[1] AAAA

Question 2(c) [4 marks available]

In the following, "odd exit" is used as a shorthand for "an exit which has been left an odd number of times". Similarly for "even exit".

At most [2] marks, taken from the following arguments. Both marks must be from the same argument.

[1] If the number of odd exits in the room is even, the room has been visited an odd number of times. Otherwise it has been visited an even number of times.

[1] The first time a spy is in a room the number of odd exits is zero (even).

or

[1] If the number of even exits matches whether the the number of exits from the room is even, the room has been visited an odd number of times. Otherwise it has been visited an even number of times.

[1] The first time a spy is in a room the number of even exits equals the number of exits in the room.

At most [2] marks from the following (which can also be phrased in terms of the even exits):

[1] Every time the spy leaves the room either an odd exit becomes even, or an even exit becomes odd.
[1] Every time the spy leaves the room the number of odd exits either increases or decreases by 1.
[1] Every time the spy leaves the room the number of odd exits switches between being odd and even.

Question 2(d) [4 marks available]

[4] 96

Question 3(a) [27 marks available]

Each test for 3(a) consists of a line containing three integers, followed by a line containing a single integer. The output should be a string of uppercase letters.

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

[1]	`1 1 1` `1`	A
[1]	`1 12 12` `1`	AAAAAAAAAAAA
[1]	`2 1 8` `2`	BABABABA
[1]	`2 2 7` `1`	AABAABA
[1]	`2 2 12` `400`	BBAABBAABABA
[1]	`2 3 10` `500`	BBABBBAABB
[1]	`6 3 10` `1234567`	AAEDFEEEFD
[1]	`6 2 8` `567890`	CCADDCFA
[1]	`8 8 8` `16000111`	HFACCBFG
[2]	`6 2 12` `1666111000`	FFBBFFCCBCFA
[2]	`12 2 12` `9876543210`	AADACFGGLBJI
[2]	`10 10 10` `7654334567`	HGFEDDEFGG
[3]	`7 2 12` `11223344556`	GFEGAFFEADAF
[3]	`10 3 12` `223344556677`	CCFCFJIFIGHE
[3]	`11 4 12` `334455667788`	BBJKBCJGCGFE
[3]	`12 5 12` `3344554433999`	EGACGKCJHCFI

Question 3(b) [3 marks available]

[1] 39
[2] 29947

Question 3(c) [5 marks available]

[1] p is odd.
[1] $r \leq q$

At most [3] marks from the following:

[1] The n^{th} plan must be the middle plan in the list of plans, otherwise its position would be different in the alphabetical and reverse alphabetical lists.
[1] For the list of plans to have a middle position it must have an odd number of elements.
[1] The number of elements in the plan which contain more than one letter is even.
[1] The number of elements in the plan which contain a single letter is odd $r \leq q$, otherwise it is even (zero).

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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 15 January 2019.**

Name of Student: Age: School Year:

1(a)

input	MMXX 3	C 1	V 1	III 2	I 7	MMXX 8	II 20	IV 20	MDCLX 30	M 50	V 50	MMDCCCLXXXVIII 50
	(1)	*(1)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*	*(2)*
output	6 2	1 0	1 1	2 1	6 2	30 12	101 37	121 46	1795 695	2858 1103	2858 1104	19013 7333

TOTAL 1(a) *(25)*

Inputs data? *(1)*
Valid output? *(1)*
Exits okay? *(1)*

1(b) *Ans: 4*
II, III, IV, IX *(1)+(1)*

1(c) *Ans: 3919* *(4)*

2(a)

input	A 1 2	C 4 8	BC 4 9	BBACC 10 1010	ABCD 50 51	FEDC 2020 876543	AABGB 5000 9999	CDCDCD 2020 876543	FFFFFFFF 512 1022
	(1)+(1)	*(1)+(1)*	*(1)+(1)*	*(1)+(2)*	*(1)+(2)*	*(1)+(2)*	*(1)+(2)*	*(1)+(2)*	*(1)+(2)*
output	BC A A BA	C C AB BB	B AC BD C CD	BC ADE AFG B B C C FG	BE AC BD CF A D CD	F E DF CE BD AC CB	BCD AFG A A G B BE AB	C D ADEG BCFH C D C D DH	F F F F F ABCDEGHIJ F F F F JA

TOTAL 2(a) *(24)*

2(b) *Ans: A*
AAAA *(1)+(1)*

2(c) *see marks scheme* *(4)*

2(d) *Ans: 96* *(4)*

3(a)

input	1 1 1 1	1 12 12 1	2 1 8 2	2 2 7 1	2 2 12 400	2 3 10 500	6 3 10 1234567	6 2 8 567890
	(1)	*(1)*	*(1)*	*(1)*	*(1)*	*(1)*	*(1)*	*(1)*
output	A	AAAAAAAAAAAA	BABABABA	AABAABA	BBAABBAABABA	BBABBBAABB	AAEDFEEEFD	CCADDCFA

3(a)

input	6 2 12 1666111000	10 10 10 7654334567	10 3 12 223344556677	12 5 12 3344554433999
	8 8 8 16000111	12 2 12 9876543210	7 2 12 11223344556	11 4 12 334455667788
	(1)	*(2)*	*(2)*	*(2)*	*(3)*	*(3)*	*(3)*	*(3)*
output	HFACCBFG	FFBBFFCCBCFA	AADACFGGLBJI	HGFEDDEFGG	GFEGAFFEADAF	CCFCFJIFIGHE	BBJKBCJGCGFE	EGACGKCJHCFI

TOTAL 3(a) *(27)*

3(b) *Ans: 39*
29947 *(1)+(2)*

3(c) *see marks scheme* *(5)*

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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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/2020/submission-record-2020.html

Please retain all student programs and scripts until 1 February.

Marks that are received after **15 January 2020** 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										Total (100) †	PC/ Lang ‡	School Year §	Age	M/F
	1a (25)	1b (2)	1c (4)	2a (24)	2b (2)	2c (4)	2d (4)	3a (27)	3b (3)	3c (5)					

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