General Tips and Format

This Puzzle Round is about a type of logic puzzle called a *nonogram*. The round will consist of three sections, with the third section further subdivided into four variants.

Sections 1 and 2 will have two puzzles each, and each variant of Section 3 will have three puzzles. In total, there are 16 puzzles.

Within each section, the puzzles are roughly ordered by difficulty. Solving each puzzle will award 10–15 points, with harder puzzles awarding more points. As such, it is recommended to try to solve easier puzzles before tackling harder ones. The maximum possible score will be 200 points.

No partial credit will be given to unfinished or incorrect puzzles, even if the errors are minor. A puzzle will only be considered finished if every cell is filled with a value. *Any puzzle with empty cells will not be eligible for credit.*

As a reminder, all puzzles in the Puzzle Round have unique solutions that can be deduced logically. If you believe that there are multiple solutions, it is likely that you have misinterpreted the rules of the puzzle. As such, it is generally not advised to follow a guess-and-check strategy when solving these puzzles.

Interface

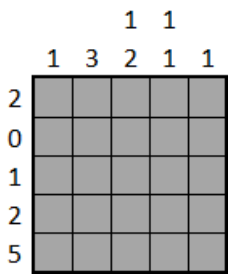
You should have received a link to a spreadsheet on Google Sheets containing a copy of the puzzles, though you will not be able to access the file yet. When time starts, you will receive access to the spreadsheet on Google Sheets, and when time concludes, your access will be revoked.

Cells will be automatically colored black or white as you fill values into them, though Google Sheets may take a few seconds to update the cell shading. You should not have to manually color any cells. More specifically:

- Any cell containing a 0 will be colored white.
- Any cell containing a 1, 2, etc. will be colored black.
- Any other cell will be colored gray.
- Section 3 Variant 4 will have an additional color.

Section 1: An Introduction to Nonograms

A nonogram is a logic puzzle consisting of an empty grid, with rows and columns labeled by lists of numbers. The following is an example of a nonogram.



The goal of this type of puzzle is to fill each cell of the grid with either 1 or 0. The numbers next to each row and above each column (which we call *clues*) indicate the lengths of contiguous groups of 1s on that row or column. We need to fill 0s and 1s into the grid to match the given clues. Here is the solution to the example puzzle:

			1	1	
	1	3	2	1	1
2	0	0	1	1	0
0	0	0	0	0	0
1	0	1	0	0	0
2	0	1	1	0	0
5	1	1	1	1	1

For example, the third column has the given clue "`1 2`". The third column sees the cells "`10011`"; as such, it contains a single 1, followed by some 0s and then two 1s in a row. We refer to a sequence of n 1s in a row as a "contiguous group of length n". From this clue alone, we could have instead filled the column with "`10110`" and "`01011`", but not "`11010`".

			1	1	
	1	3	2	1	1
2	0	0	1	1	0
0	0	0	0	0	0
1	0	1	0	0	0
2	0	1	1	0	0
5	1	1	1	1	1

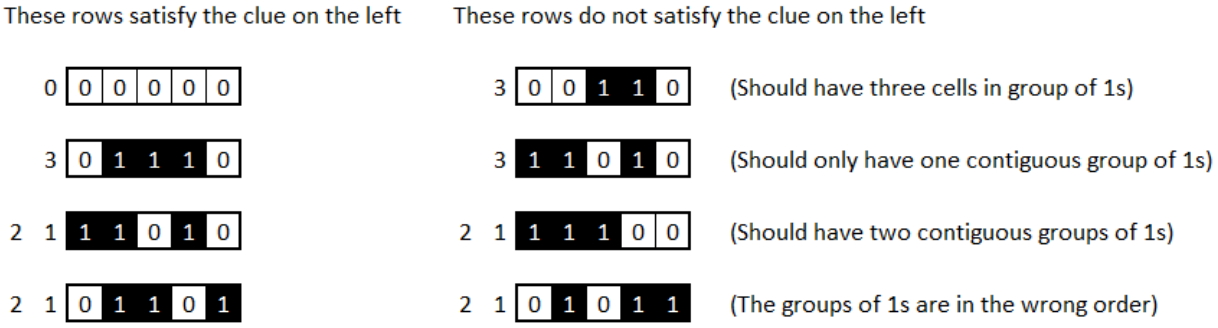
A row or column with a clue of "`0`" indicates that there are no 1s in that row or column, as in the second row of the example above.

Throughout these instructions, and in the spreadsheet you will be provided, we use gray to denote cells that have not yet been filled, white for cells containing 0, and black for cells containing 1. The colors are to aid in readability, and are not otherwise part of the puzzle.

The rest of the Puzzle Round builds on the mechanics of the nonogram, so it is a good idea for all members of the team to familiarize themselves with the rules in this section. The following page has some tips on how to solve nonograms.

Examples of Valid Nonogram Configurations

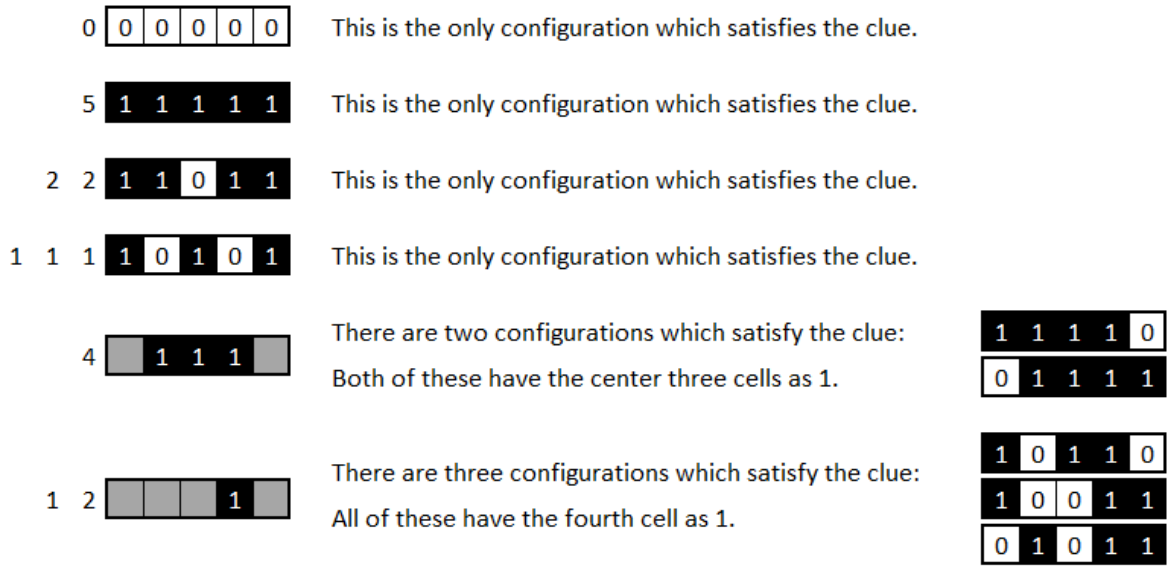
One common strategy for solving nonograms is to look at a single row or a single column at a time. Here are some example of configurations that satisfy or do not satisfy their corresponding clues.



Tips on Strategies for Solving Nonograms

Here are some examples of clues that determine a lot about how to fill in their corresponding row or column. Clues like these provide good starting points for solving a nonogram.

In each example below, we present what can be deduced given the clue on the left. Gray cells denote cells which you can't deduce from the clue alone. Try and determine why the given cells can be deduced!

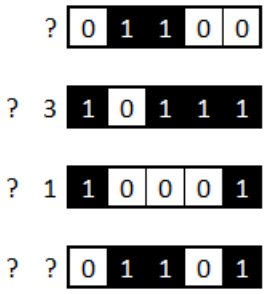


Section 2: The Question Mark

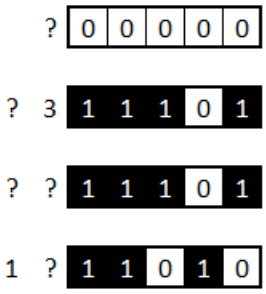
In this section, we introduce the question mark clue. Question marks represent contiguous groups of 1s, as we saw with number clues, but they can correspond to a group of any nonzero length. For example, the first row of the example has the given clue "`? ?`", and the filling of that row has two contiguous groups of 1s. Question marks can only correspond to nonzero values. In particular, a row with the clue "`?`" cannot be a row with only 0s.

Other than the above, all normal nonogram rules apply.

These rows satisfy the clue on the left:



These rows do not satisfy the clue on the left:



(? can't be 0)

(The second contiguous group of 1s only has one cell)

(There are only two contiguous groups of 1s, not three)

(There's no contiguous group of 1s corresponding to the last ?)

Section 3: Nonogram Variants

Section 3 consists of four variants on the standard nonogram rules.

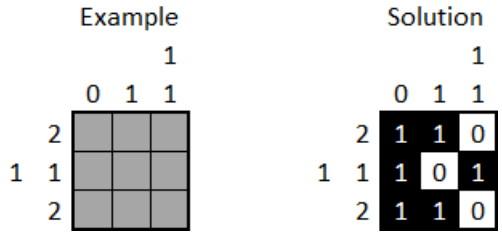
The puzzles in this section may also contain question marks, so we recommend understanding the mechanics of the previous sections before moving on to this section. In addition, some of the harder puzzles may have no clues provided for some rows or columns; this indicates that no information is given on that row or column.

Variant rules only apply to the puzzles listed for that variant. In other words, the special rule for Variant 1 only applies to the puzzles in Variant 1. This means that the variants can be done largely independently. Unless otherwise stated, the nonogram rules used in Sections 1 and 2 all apply.

The variants are roughly ordered in terms of difficulty, and each variant consists of an easy, medium, and challenge problem.

Variant 1: Reverse Clues

The clues given for columns specify the contiguous groups of 0s, instead of the groups of 1s. Row clues are unaffected.

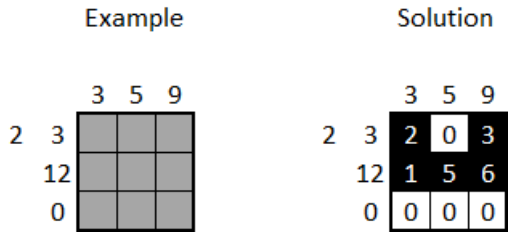


In the above example, note that the third column clue is a "`1 1`", as there are two groups of 0s in that column. The row clues are unaffected by this rule change. For example, the second row is also a "`1 1`", as it has two groups of 1s in that row.

Hint: Most normal nonogram strategies are applicable to this variant.

Variant 2: Multi-cells

In this variant, black cells are allowed to contain positive integers greater than 1. Clues give the sum of numbers in contiguous groups of black cells.

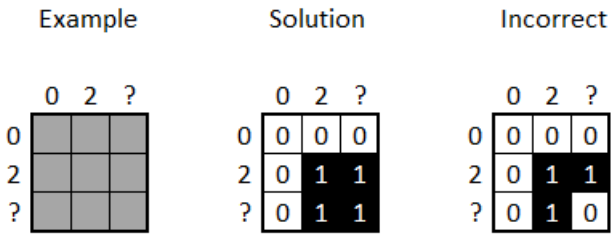


In the above example, we see that the second row has the clue "`12`", because $1 + 5 + 6 = 12$. The first row has the clue "`2 3`", as there is a group which sums to 2, followed by a group which sums to 3.

Hint: When solving the puzzle, it may be helpful to temporarily mark cells which must be nonzero.

Variant 3: Connected

In addition to standard nonogram rules, in this variant, the 1s must form a single connected component, and the 0s must also form a single connected component. Diagonally adjacent cells are not considered connected.



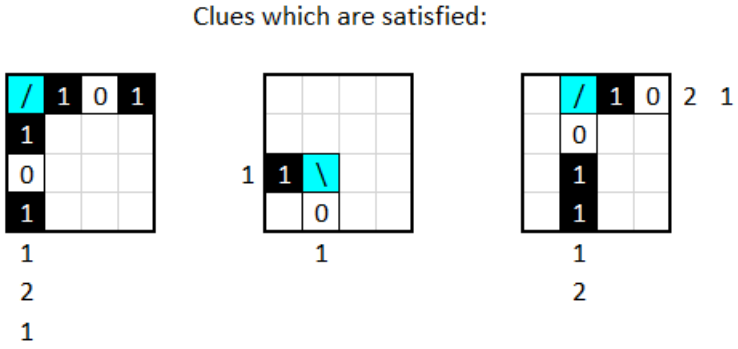
In the above example, note that both the grid marked "Solution" and the grid marked "Incorrect" satisfy all the clues on the outside. However, the grid marked "Incorrect" has two separate connected components of 0s; as such, it is not the solution to the puzzle.

Hint: The connectedness requirement is very restrictive. Many cells will be forced to be 1 or 0 just from the connectedness rule alone.

Variant 4: Mirrors

Each row and each column contains exactly one mirror: either \ or /. Our interface will color these cells light blue. Clues give information based on "line of sight" by bouncing off a mirror at a 90° angle, with the clues listed in the order that the contiguous groups are seen (much as in normal nonogram clues).

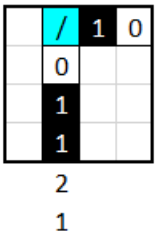
Mirrors don't count as 0 or 1; as such, they don't count as part of a group of 1s, but at the same time, they don't break or interrupt a contiguous group of 1s.



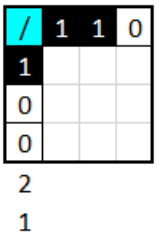
In the first example under "Clues which are satisfied", the mirror is placed in the upper-left corner. The clue given sees, in order, the cells "`101/101`", where the "`/`" is a mirror. The clue ignores the mirror for the purposes of determining contiguous groups, and thus sees "`101101`"; as such, the clue reports three contiguous groups of "1"s, of length 1, 2, and 1, respectively.

Here are some more examples for Variant 4:

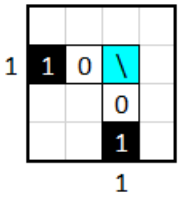
Clues which are not satisfied:



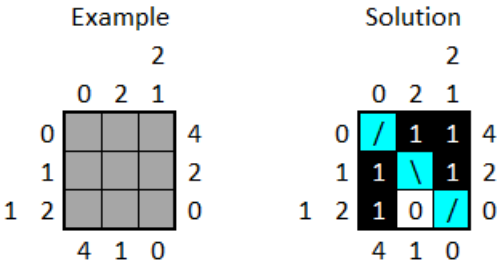
(The groups of 1s are in the wrong order)



(Mirrors do not break contiguous group of 1s)



(Should only have one contiguous group of 1s)



Hint: It may be useful to keep track of the cells that can or cannot contain a mirror. As a reminder, there is exactly one mirror in each row and each column.