Puzzlecraft

How to Make Every Kind of Puzzle

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discover the same fact. The 1234 on the top of this puzzle, for example, identifies 1234 and 5678 subgroups that can then be filled in from a few of the givens below to get started.

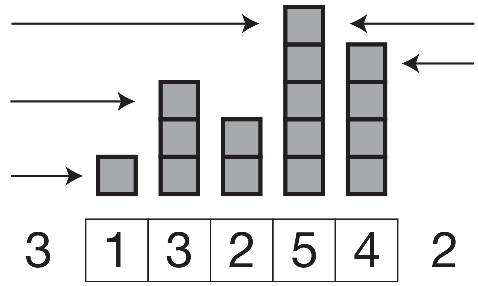
5. Test your puzzles out on some friends

However you've varied the sudoku recipe, it's worth seeing how approachable the new challenges are for other people. The leaps of logic that seemed obvious to you when you went about constructing the puzzle might not be as easy for your solvers to grasp, and some test-solving will help you gauge if you need to make your puzzles easier or harder.

While I don't use the computer to construct these variations, I've found in making many of these types that it is helpful (if you know how to code such a thing) to write a solver that can check that there is only one solution to the puzzle. It's easy on a "new" type to overlook something, or to make a mistake, so having an automated check, or a check from a trusted solving friend, is an absolute must when you venture into uncharted waters.

CRAFTING A SKYSCRAPERS PUZZLE

While most paper puzzles are confined to just the two dimensions of the page, skyscrapers puzzles can evoke a third dimension as solvers visualize the buildings sticking up out of the page. With a mental image like the one to the right for a single row of a city, solvers can recognize why only three buildings (the 1-, 3-, and 5-story buildings) are seen when looking from the left side and two are seen from the right, for example. The following tips will hone your architectural skills.



1. Work backward from an answer

Make a valid N×N Latin square that can be a puzzle answer; I found 5×5 and 6×6 to be good sizes to start exploring. Then, make a blank grid and put all 4N clues on the outside exactly as in the answer. Try to solve this puzzle and see if it has just one solution; if so, remove some of the clues to leave a harder puzzle and repeat this process until satisfied. While this method works for small puzzles, you will often run into invalid grids with multiple solutions for larger sizes, which generally means you should start over.

Doing this exercise, you can learn a lot about the importance of different clues in a skyscrapers puzzle. 2s and 3s don't immediately give a lot of information. On the other hand, 1s give instant placements on the edges (and there must always be a 1 on each edge). In most cases you won't want to give too many 1 clues, but erasing only the 1 clue on an edge won't work either, as the single missing clue can still be easily identified as a 1. Try to erase at least two or three digits from each side to leave a valid 5×5 puzzle with eight to ten clues.

2. Work backward from a more interesting answer

Repeat step one but now, when filling in a solution, place numbers that leave opportunities for good clues. You can fill a row or two where all N buildings are observable (leaving an easy N clue); it's also incredibly valuable to set up N−1 clues or N−2 clues where possible. Having two N−1 clues on the same edge is very constraining, as is three N−2 clues. Another interesting situation logically is any row or column where *all* buildings are observable from one of the two directions (such as having a 3 on each side of a row in a 5×5 puzzle). In this situation, having ascending heights on both sides places additional limits on where the small or large numbers go, and often allows one placement to chain deductively to the opposite side. By setting up good skyscrapers clues in the answer, working backward to get a good puzzle is much easier.

This is the approach I took with the first 5×5 puzzle. I wanted a grid that had a lot of 4 clues, so I positioned

Latin Squares

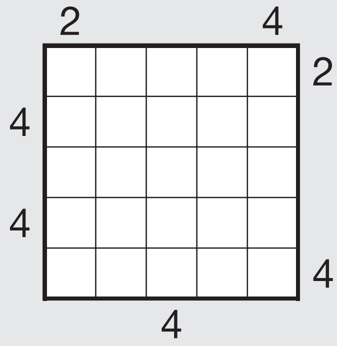
A Latin square is an N×N grid of boxes, with each box filled by one of N different symbols so that no symbol repeats in any row of column. The name was motivated by the work of the mathematician Leonhard Euler, who did some of the initial studies on the combinatorics of Latin squares using Latin characters as the symbols.

Numbers can also be used as the symbols in a Latin square, with the digits 1 to N being most common. We've seen this exact situation in sudoku, although a sudoku solution is a special subset of Latin squares, as the 3×3 regions place additional constraints on the placement of the symbols. For those counting at home, there are approximately 6.67×1021 valid 9×9 sudoku solutions, but there are many more (5.52×1027) different 9×9 Latin squares. In neither case do we run the risk of running out of different puzzles in our lifetime. Latin squares form the basis for many different puzzle types, including the ones described on the next few pages.

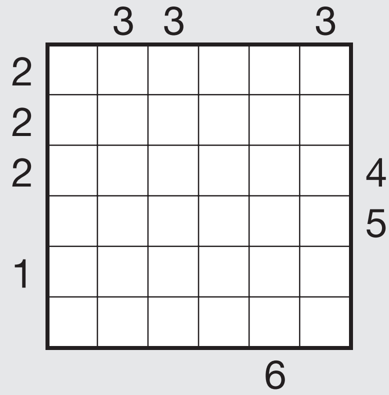
SKYSCRAPERS

For each N×N grid, place a number from 1 to N into each cell so that no digit repeats in any row or column. Each number represents the height of a skyscraper. The clues on the outside of the grid indicate how many skyscrapers can be seen when looking at that row/column of the city from the outside. Taller buildings block the view of any smaller buildings behind them. In the last puzzle, instead of the number of buildings seen, the outside clues indicate the sum of the buildings seen.

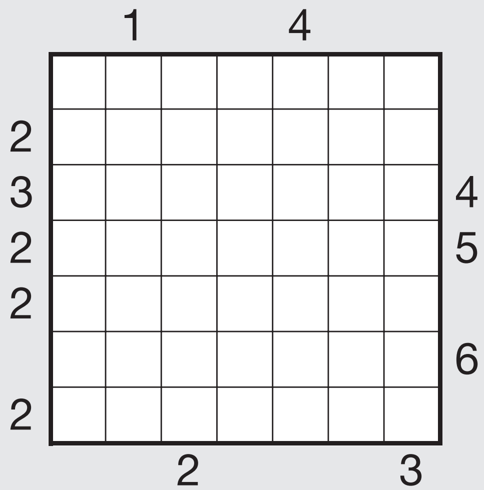
5×5 skyscraper



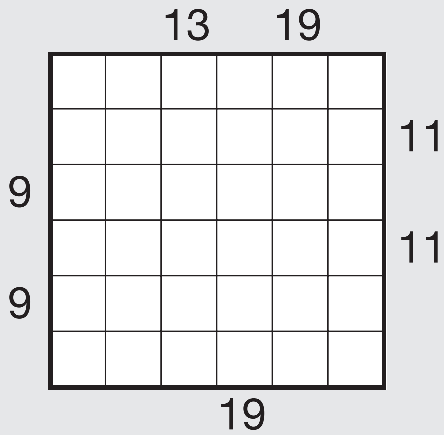
6×6 skyscraper



7×7 skyscraper



6×6 additive skyscraper



the first several numbers to leave behind a lot of rows and columns where four buildings were seen. In choosing the clues I started with all the 4s I could give in the grid and found adding in just a few (pseudo-symmetric) 2s would complete a good puzzle.

3. Work forward with interesting clues

The first two steps have given you a bit of practice in figuring out what clues to start from and what clues can be removed entirely. Now you can work forward from a blank grid. You'll set up some of the same "interesting" situations mentioned in step two by placing the relevant clues on the outside of an unsolved grid and pretending to solve the puzzle as you are constructing. The first step is often placing all the large buildings, and you can consider where clues appear as a strategy for accomplishing this. Marking some clues as ≥2 or ≥3, for example, can help, as this removes the largest and second largest buildings from the nearby cells. Add clues until you force a single answer, then replace the ≥ clues with the actual numbers to finish the puzzle.

In the 6×6 puzzle, I tried to showcase every possible clue value (from 1 to 6) going clockwise around the grid from the bottom. Both the 1 and 6 are very forcing clues, so I started with those. This didn't leave a lot of places where the 5 could be on the right side, and I found I needed several 2s and several 3s (which don't tell as much) to finish off the puzzle.

In the 7×7 puzzle, instead of trying to make a visual theme, I incorporated a very hard solving theme. One *thing you will learn about 2s is that when the largest building size is completely separated across the grid, then the second-largest building size must immediately touch the 2 clue. This puzzle would take that concept to an extreme. You'll likely find you can enter about five digits really easily (four 7s and a 6) but then get stuck. There are three rows left (all with 2 clues on the left side) that must take a 7 in the fifth, sixth, or seventh columns. One of these must be 6XXXXX7 as described above, but the next one must be 5XXXX76 and the last 4XXX765 because big buildings must be hidden behind the 7 to continue to satisfy the 2 clues. The 3 on the bottom right is the clue that forces an order for these three rows, and puts in enough digits to force most of the rest of the grid. I had to add one or two more column clues to specify just one answer, but that hard initial step is the real meat of the puzzle.*

4. Add some variety

For variety, add some additional constraints to these puzzles, such as allowing "gaps" in the city, where one square per row/column does not contain any building whatsoever. Other region constraints (such as sudoku-like regions or things like domino sets) can be used. The outside clues can also be changed to involve arithmetic like the "sum of visible buildings" or "product of visible buildings."

Here, I tried an arithmetic variation with a few different features. Specific arithmetic values now can specify a particular set of visible buildings. A 9 clue, for example, can mean seeing 1, 2, and 6, or 3 and 6, but in either case the 4 and 5 must be hidden at the other end of the row or column. In this puzzle I chose some different numbers with different possible subsets of buildings, and then balanced their positions to get different deductions chaining together, one into the next.

CRAFTING A CALCU-DOKU

In the mid-2000s, calcu-doku puzzles began to populate the shelves of bookstores with several names, including KenKen (or, when hand-crafted by me, TomTom), but always with the buzz of being the "next sudoku!" While I'm skeptical of the merit of this marketing, calcu-doku, a mathematical puzzle with fairly simple rules, does share its Latin square ancestry with sudoku. The addition of arithmetic to a number-based puzzle separates calcu-doku from sudoku, and makes this a good choice for exploring the construction of puzzles involving mathematics.

1. Choose a grid size

The size of a calcu-doku grid helps determine its difficulty, because the range of numbers opens up more possibilities for the operations. For example, the clue 7+ in two cells (indicating that the two digits within that region add up to 7) can be $2+5$ or $3+4$ in a 5×5 puzzle, but in a 6×6 puzzle can be $1+6$ or $2+5$ or $3+4$. Larger sizes also add complexity to operations like multiplication and division, where the first time a 2-cell product can be expressed in two ways is $1\times 6 = 2\times 3 = 6$.

I picked a range of sizes from 5×5 to 8×8, with the smaller sizes demonstrating easier techniques (such as showing off the basics of addition in the 5×5 puzzle), and the larger puzzles offering more types of themes and challenges.

2. Choose some region shapes

Your puzzle will need bold regions, often called **cages**, to uniquely determine the solution. Most puzzles currently on the market are computer-generated and have randomly oriented regions. If you are hand-writing these puzzles, you might choose some symmetric and interesting shapes as one route to making a more aesthetically pleasing puzzle.

Single-cell regions can be used to instantly give the solver a number and a place to get started. Two-cell regions are most common, with several values for a given operation that may uniquely define a pair of numbers that goes in that region. As the sizes of the regions increase, the puzzle gets harder. Use more 2-cell regions if you want an easier puzzle; try more 3-cell, 4-cell, or larger regions if you want a harder puzzle. Because a number can repeat in a bold region if it spreads across multiple rows and columns, having bendy region shapes for multi-cell regions is also a way to make the puzzle harder. If you use 2-cell regions, make sure some are horizontal and some are vertical, or else you won't constrain the puzzle enough along the rows and the columns.

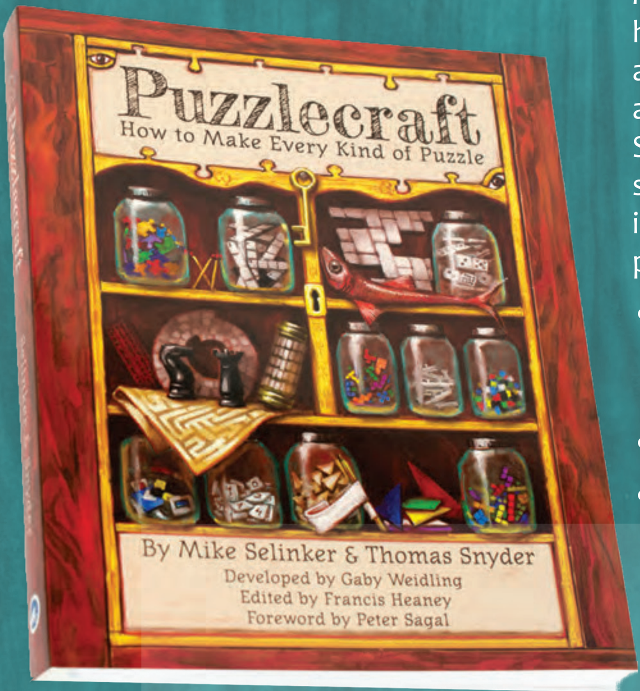
For the 5×5 puzzle, I started with a plus sign–shaped region in the middle to match the addition-only puzzle. For the remaining regions, I chose a mix of 2- and 3-cell regions with the top and bottom row having regions that extend just one cell into the adjacent row. These would end up being the first digits in our solving path based on geometry constraints.

For the 6×6 puzzle, I chose a mix of horizontal and vertical cages that split the grid into quadrants. One operation would be used exclusively in each quadrant, and the larger cages were selected for the addition and multiplication corners.

For the 7×7 puzzle, I did something unusual and only used horizontal cages, like in a brick wall. This type of design is very challenging to construct, with only the offset of adjacent rows allowing digits to get into the middle of the grid from left to right.

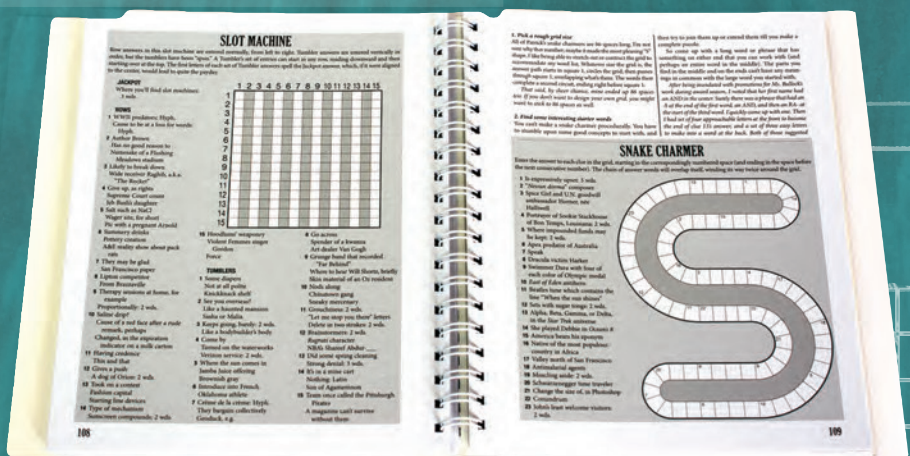
Puzzlecraft

How to Make Every Kind of Puzzle



Puzzlecraft is the only book that teaches you how to make every kind of puzzle. Seven years after its initial publication, this heavily revised and expanded book from puzzlemasters Mike Selinker and Thomas Snyder contains over 100 sections of step-by-step instructions on making individual puzzle types, each with accompanying puzzles.

- New sections on escape rooms, interactive fiction, puzzle rallies, new Japanese logic puzzles, videogame puzzles, and more
- Foreword by NPR quizmaster Peter Sagal
- New adventure in the Maze of Games world



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