Puzzle Ninja Ninja

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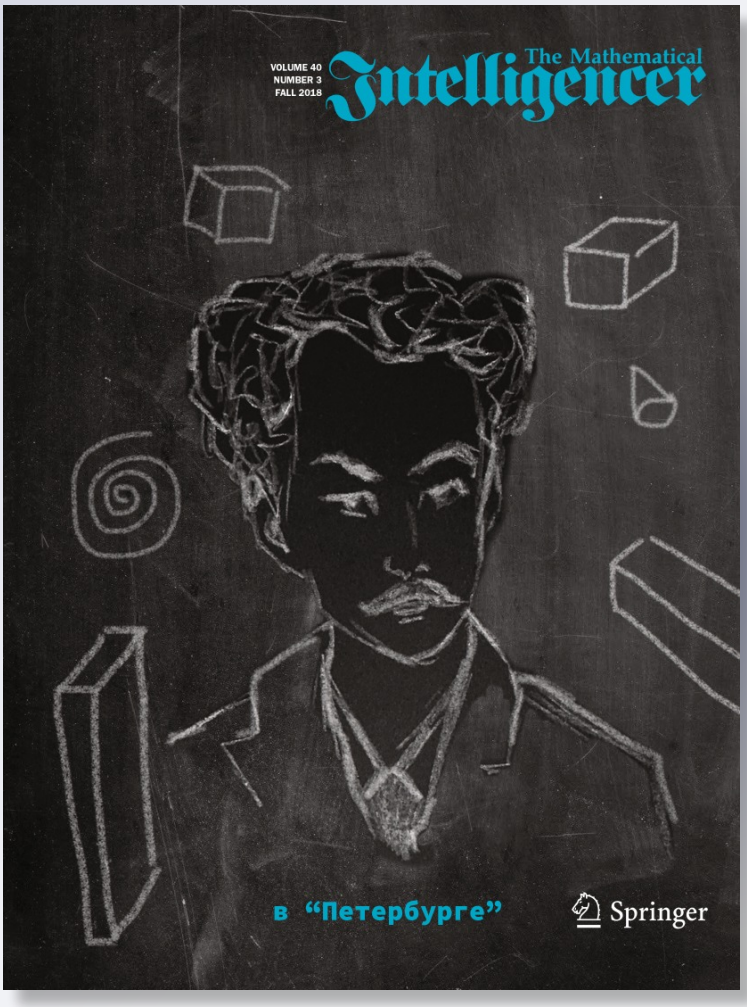

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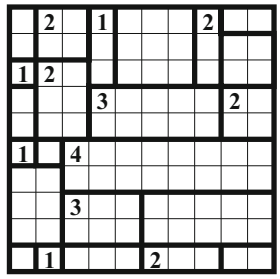
Jim Henle

This is a column about the mathematical structures that give us pleasure. Usefulness is irrelevant. Significance, depth, even truth are optional. If something appears in this column, it's because it's intriguing, or lovely, or just fun. Moreover, it is so intended.

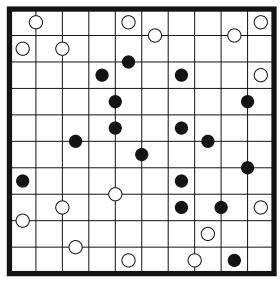
For months I had been planning to write a column about the Japanese puzzle scene. That scene is an artistic and mathematical phenomenon. It's populated by hundreds (thousands?) of dedicated, creative, logical souls who are bringing to life beautiful, enigmatic, and tantalizing puzzles. How did this happen? What has been accomplished? Where is it all going?

It's a great story, but I don't need to tell it, because Alex Bellos has already done it with a practically perfect book: *Puzzle Ninja*.[1] It's an introduction to the players, the history, and the pleasures of Japanese puzzles, and it is marvelous on several levels.

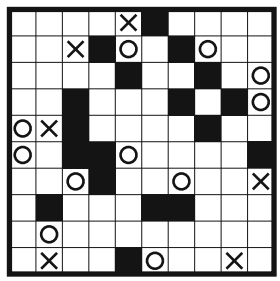
By the number of dedicated pages, *Puzzle Ninja* appears to consist chiefly of puzzles,



hundreds of them,



of at least twenty-five different varieties



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[1]Guardian Books, London, 2017; Chronicle Books, San Francisco, 2018.

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(a Heyawake by Yuma Miyaij, a Tentai Show by Katoryu, and a Marupeke by Naoki Inaba).[2]

The puzzles attract, excite, and bewilder, but what I most enjoy in *Puzzle Ninja* is the commentary. To call Alex a "fan" is too mild. To call him a "connoisseur" is too fussy. What he is, is a consummate *appreciator:*

> As you fill in the grid [of a Shakashaka] you feel like you are an archaeologist excavating ancient ruins ...
>
> At any point [in solving a Nurikabe] you have one of two perspectives: are you following where the river must flow, or are you thinking where the dry land must be? ... The tension between these two perspectives is thrilling.

Alex recommends trying easy puzzles first. That helps you learn about the puzzle type, of course, but then he adds, "Simple puzzles have a different taste. Savour it."

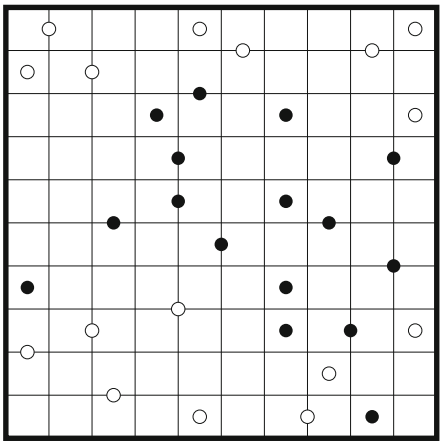
If puzzles were edible, I would call Alex Bellos a *gastronome*. Instead, I am calling him a *puzzle ninja ninja*.[3]

Given the publication of Alex's book, I will devote this column to a discussion of the mathematical pleasures of puzzles.

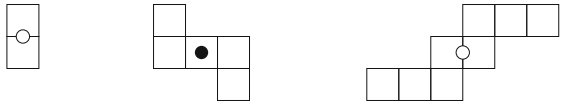
Puzzle Pleasure I

There are at least three ways in which puzzles provide pleasure that I would call "mathematical." The first is the joy we experience when we tackle them and (perhaps) solve them. As Alex Bellos describes, it is a multitextured pleasure.

I'll give you two examples of puzzle types from *Puzzle Ninja*, both among Alex's favorites. The first is the Tentai Show. Here is the puzzle I showed earlier, more decently sized:



The challenge of a Tentai Show is to divide the puzzle into regions composed of squares that are "twofold rotationally symmetric," that is, the region must appear unchanged when rotated through 180°. Finally, each region must contain exactly one circle, which by the symmetry requirement must be in its center. Examples:



That seems pretty straightforward, but there are surprises. The puzzle shown above is ranked "hard" in the book (watch for an especially intricate symmetric region). *Puzzle Ninja* has easier Tentai Show puzzles—and more difficult ones.

As a plus, if you shade in the regions that have a black dot in the center, you are rewarded with a picture.[4]

My other example from *Puzzle Ninja* is a KenKen handmade by Tetsuya Miyamoto. It's not quite the same as the KenKen you see in newspapers and magazines.[5]

21		30	36		40	14	7
7	60						
			28		14		
2	48	42		7			15
		20		280			
84	6				10		15
		56	3		30		
4			24			24	

In most KenKen puzzles, in every region you're given a number and an operation ($+$, $\times$, $-$, $\div$). The goal is to place digits in the region in such a way that it is possible to compute the given number using the given operation. After a time, Miyamoto realized that you can compose wonderful puzzles in which the operation *isn't* given and you have to discover what operation will work. As in ordinary KenKen puzzles, each row and each column must have one of every number up to the length of the side (in this case, 8).

Thus, for example, the digits for the two-square region

10	

in the above puzzle might turn out to be a 4 and a 6, or a 3 and a 7, or a 2 and an 8 (with the operation addition), but they might instead turn out to be a 2 and 5 (with the operation multiplication). Amazingly, there is one region in

[2]The illustrations here and throughout this article are mine.

[3]The "puzzle ninja" of the title is Edamame, a former winner of the World Puzzle Championship. Edamame is not his real name; it's his *nom de mystère*.

[4]It goes without saying that a Tentai Show puzzle must have a unique solution. Uniqueness is an important puzzle (and mathematical) aesthetic, and it is shared by all the puzzles in Puzzle Ninja and all the puzzles in this column. I will post the answers to this puzzle and the other puzzles in this column on the column website: www.math.smith.edu/~jhenle/Pleasingmath/.

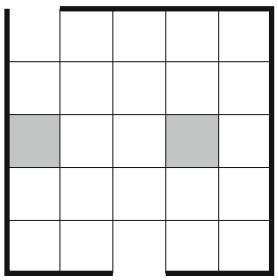
[5]Where "KenKen" is registered as a trademark of Nextoy, LLC.

that puzzle where eight different number combinations (and *all four* arithmetic operations) are theoretically possible. Very cool!

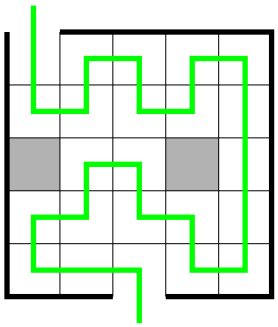
Puzzle Pleasure II

A puzzle type can give a different sort of pleasure if it leads to interesting questions, conjectures, and theorems. Many mathematicians labored hard, for example, to solve the mathematical question of the minimum number of clues necessary for a sudoku puzzle.

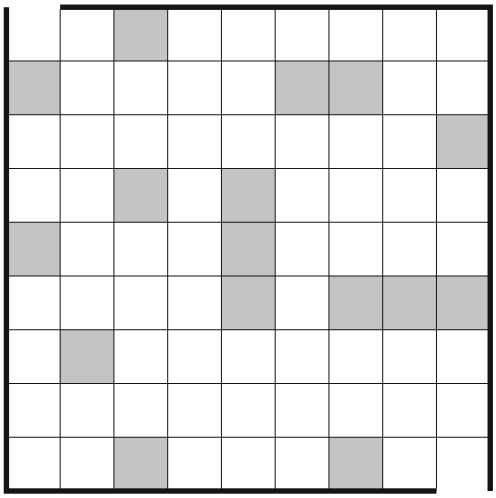
Last year, Jesse Azevedo, one of my students, invented a puzzle form that has been puzzling me mathematically. She called it "Keep Calm and Puzzle On":



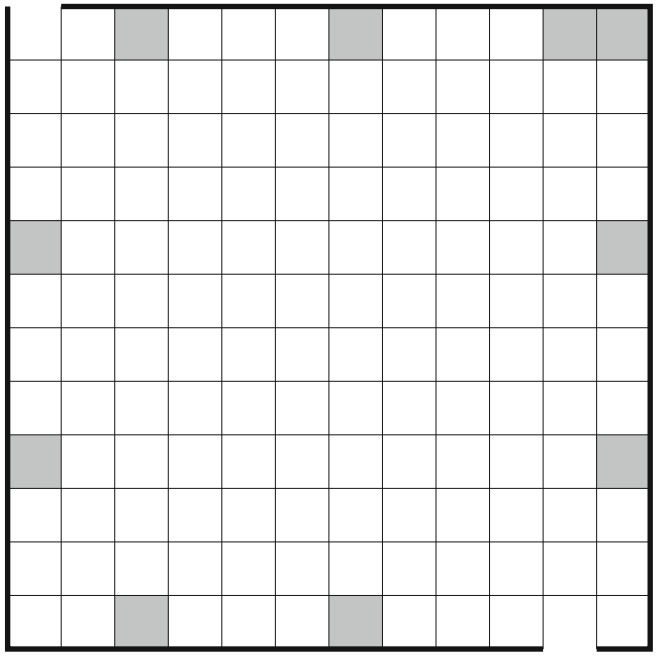
The rules are quite simple. You are to construct a path from one opening to the other. The path should be composed of horizontal and vertical segments, should not cross itself, and should pass through the center of every white square.



Here's a larger Keep Calm puzzle to play with:



The question of the minimum number of clues for a Keep Calm puzzle is intriguing. The 5 × 5 puzzle had only two blocks. That's eight percent of the puzzle blocked out. I later found a 12 × 12 puzzle that needed only ten blocks (less than seven percent).



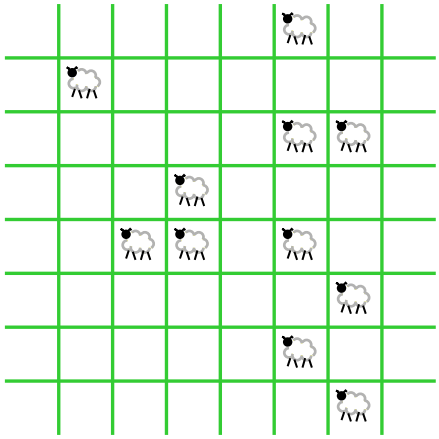
I'm confident that this can be reduced indefinitely for larger puzzles, but what's the minimum for, say, a 12 × 12 puzzle? It's less than 10, but I don't know what it is exactly. Perhaps a reader can help.

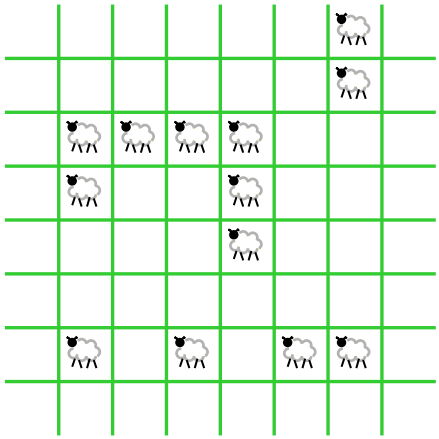
Puzzle Pleasure III

Particularly successful puzzle types attract creators. It's great fun to compose puzzles when the puzzle type allows for interesting diversions and strategies. From the range of puzzle authors in *Puzzle Ninja* it's clear that the puzzle types that Alex chose provide this third class of puzzle pleasure. This pleasure is distinct from the other two. Sudoku, for example, is an enormously successful puzzle type in terms of pleasures I and II, but it's less successful in terms of pleasure III. Most sudoku puzzles are created with software.[6]

A puzzle exhibiting pleasure III is Save the Sheep, a puzzle type I introduced two columns ago. It was invented by EvaMarie Olson, one of my students. I was disappointed but not surprised when Donald Knuth wrote me to say that the Save the Sheep puzzle I had offered had 62 solutions (a violation of puzzle aesthetics). But I was excited when he sent me a sheet of more than a dozen Save the Sheep puzzles he had written. The puzzles are most enjoyable. Here are two of them:

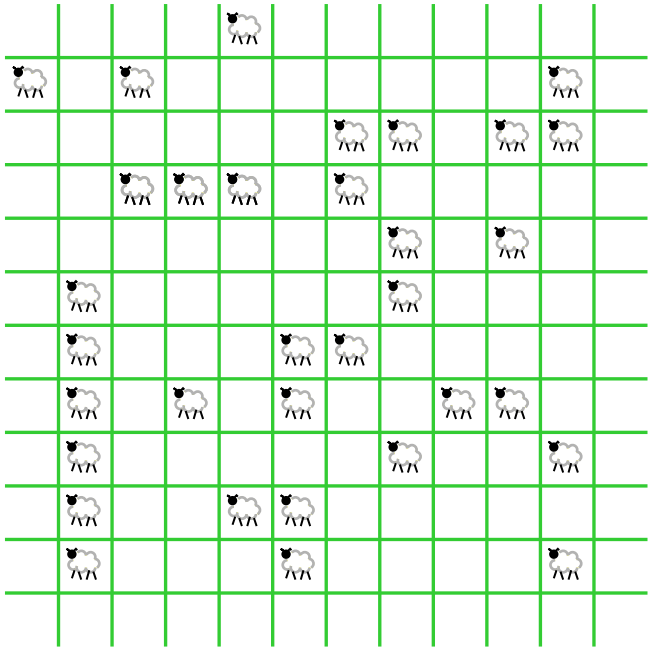
[6]Note that I described Miyamoto's KenKen as "handmade." Most commercial KenKen puzzles are produced by computers. All the puzzles in *Puzzle Ninja* were handmade.





To solve a Save the Sheep puzzle you must erect a fence with all the sheep on one side. The fence must begin and end at a side of the grid. It can't visit any lattice point twice. Lastly, the fence must include exactly two sides of each sheep's square.

These should keep you busy for a while, but here is a much more difficult Sheep puzzle, also written by Don:

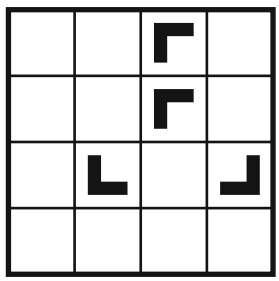


Puzzle Aesthetics

Two of the most important criteria of puzzle beauty are seemingly contradictory: simplicity and complexity. But by "simplicity" I mean that a puzzle is especially nice if it is simply presented, that is, if the rules are easy to state and understand. And by "complexity," I mean that a puzzle is intriguing if it's tricky to solve, if it requires novel strategies and ideas. *Simple to state; complex to solve.*

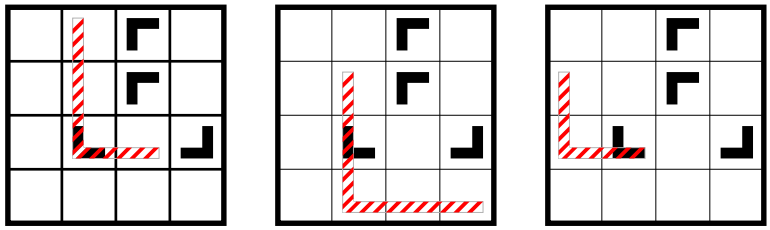
I will close with a contribution from another of my students, Ray Ren.[7] It's a puzzle type that sports both aesthetic traits. We can call her puzzles "Candy Cane" puzzles.

A puzzle of Ray's has ells in it.

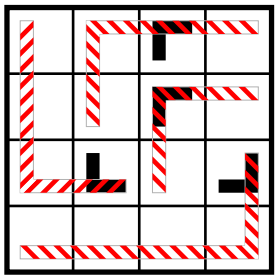


You are to place an elongated ell-shaped candy cane over each ell. The candy cane should have the same orientation as its ell, but a cane can stretch over adjacent empty squares. For example, on the bottom left ell you could place any of these candy canes:

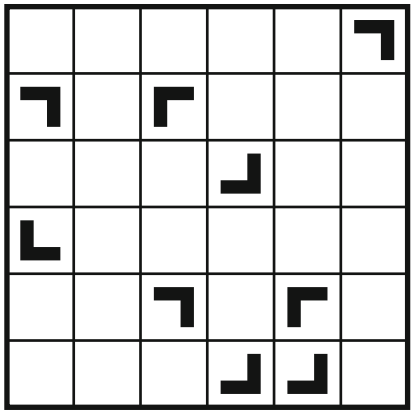
[7]My students, by the way, are not mathematicians or scientists. They are undergraduates. Ray is a history major. EvaMarie is majoring in East Asian studies. Jesse majored in theater and government. The capacity to create something mathematically pleasurable is more widely spread than the possession of mathematical knowledge or mathematical sophistication.



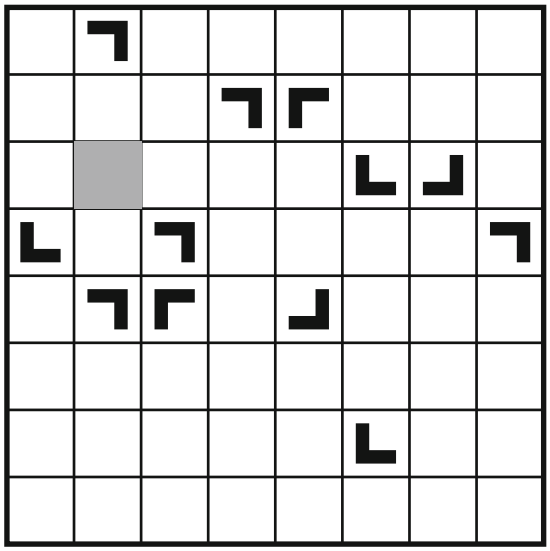
The goal, naturally, is to fill the square with nonoverlapping candy canes:



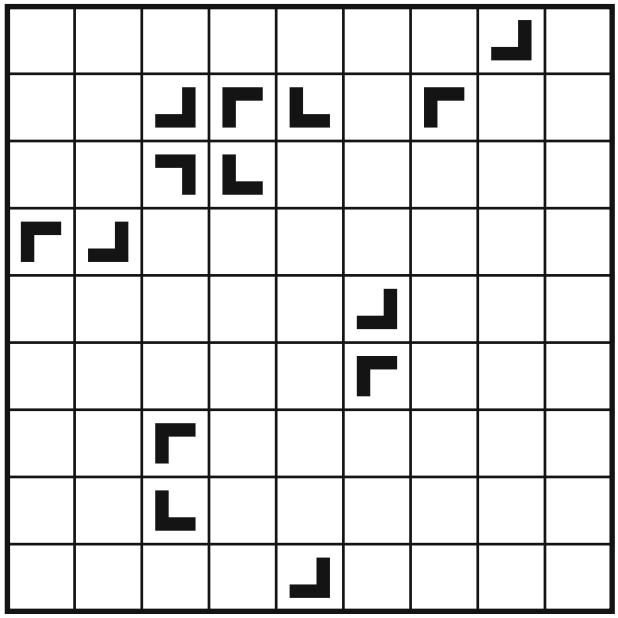
I'll give you two of Ray's puzzles. First, a 6×6 puzzle:



And second, an 8×8 puzzle (here you are to cover all squares except the gray one):



I felt the tug of pleasure III as soon as I saw these puzzles. Here is a result of my labors:



As always, you can write me at pleasingmath@gmail.com. And answers and comments (yours and mine) will always be available at www.math.smith.edu/~jhenle/pleasingmath/.

And finally, while I strongly recommend that you run out and buy Alex Bellos's *Puzzle Ninja*, you can easily find problems and explanations to various puzzle types (including Heyawake and Marupeke) on the web.

