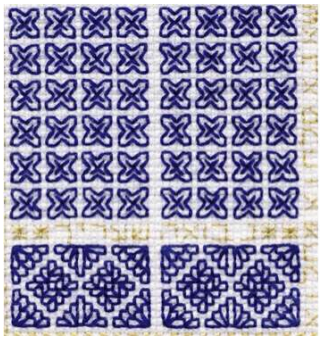
The Mathematical Basis of Blackwork

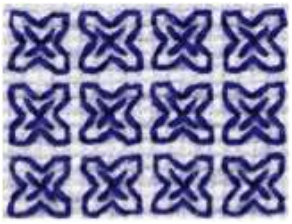
Blackwork embroidery design is highly mathematical. The discussion of *Bamidbar* (page 19) refers to geometric elements such as symmetry, translations, rotations, and reflections. Algebraic and other geometric concepts are also at play in crafting a good pattern.

Consider the *Gates of Repentance* patterns on page 26. The pairs of gates in the lower left corner must be equally wide, so that they share a common column of gold-threaded Hebrew text on their right.



One "door" of the gates depicted below—the one with rosettes and fan shapes—is 19 spaces wide.

Similarly, the door of the gate above it, featuring cross-hatched x's, is 19 spaces wide. The pattern consists of 4 x's,



each 4 threads wide, one space apart from the next. That results in a width of 19, since (4×4) + (3×1) = 19. *Quod erat demonstrandum,*[1] so to speak.

A second example may be seen in *Mishkan*, pictured on page 14. The fourth Torah column includes an alternating fan pattern, some text, and a blue bracketed flower pattern that repeats every four spaces.

In algebraic language, the bracketed flower pattern is 'modulo 4.' It is stitched into a column that is 40 spaces wide, so there is room to stitch 10 black brackets.

[1]Latin for that which was to be proved. This phrase or its initials, QED, may be found at the end of mathematical proofs. My discussion gives an example, not an actual proof!

Let us turn now to the fan pattern at the top of the column. The counts of the fan and flower patterns have to match to achieve a uniform column width. Upward-pointing fans are 8 spaces wide, and downward-pointing fans are 9 spaces wide. The motif that repeats in the row of fans is 13 spaces wide; it looks like this:

The two patterns, fans and flowers, would align perfectly if placed into a column 52 spaces wide, since 52 is the least common multiple of 4 and 13. A column that wide would contain exactly 13 brackets of the flower pattern and 4 full repetitions of the fan pattern. But such a column would be too wide for the overall embroidery piece.

Instead, consider three repetitions of the fan pattern: 3 × 13 = 39 is awfully close to 40, the width of the flower pattern! So the middle fan is stitched with base 9 spaces wide, instead of 8. It's still easy to put symmetry into that fan itself, and in fact, the entire column is still symmetric around the middle of that fan. So the row of fans fits into the 40-space-wide column and is still visually appealing.

Fun with so-called modular arithmetic in the design, and when it's all over, you get to stitch, too!

Angles within the patterns also play a role in blackwork design. In *Asarah Levushim* (page 50), ten wedges emanate from the chorus of words in the upper right, each wedge