

Appendix 1: NOTES ON SUDOKU DESIGN

Sudoku puzzles look very mathematical, but are they? The answer is, No; the numbers are only used as symbols, with no intrinsic mathematical significance. The only requirement is that nine different symbols must be found in every row, every column, and every 3x3 box. Plate A.1 shows a particularly orderly arrangement in which the symbols are numbers from 1 to 9. This is only one of many, many possible Sudoku matrices, as will be seen in Appendix 2. Employing numbers for the symbols is the customary practice, but one could just as well use the first nine letters of the alphabet (Plate A.2), or as a chemistry newsletter did recently, the symbols of the first nine elements of the Periodic Table (Plate A.3). Plate A.4 has a set of nine conventional typewriter symbols instead. You even can permute the digits in a systematic manner as in Plate A.5 where every 1 has been replaced by an 8, every 8 by a 2, every 2 by a 3, etc. These plates are all absolutely equivalent. One can write a conversion table that will change any one of these five plates into any other:

| | | | | | | | | | |
|------------|---|----|----|----|---|---|---|---|---|
| Plate A.1: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Plate A.2: | A | B | C | D | E | F | G | H | I |
| Plate A.3: | H | He | Li | Be | B | C | N | O | F |
| Plate A.4: | ! | @ | # | \$ | % | £ | & | * | ≈ |
| Plate A.5: | 8 | 3 | 1 | 6 | 4 | 9 | 7 | 2 | 5 |

Going from one of these forms to another is like solving a simple substitution cryptogram. Numerical symbols are preferred because numbers are easier to keep track of. Plate A.5 has an additional advantage over Plate A.1. If someone is solving a Sudoku puzzle using the symbols of Plate A.1, the thought may occur that the creator of the puzzle had laid out digits in their normal 1–9 order. This would tempt the solver to take a shortcut, and would subvert the logical process that is supposed to be employed. So in a sense, Plate A.5 is a disguised version of Plate A.1.

Of course there are many possible complete Sudoku matrices that satisfy the 1–9 row/column/box rule. Starting with Plate A.1, one can interchange any two rows within the same three horizontal boxes. In Plate A.6, rows 2 and 3 have been interchanged. This now is a truly different Sudoku solution; there is no way you can permute or change the nine symbols and turn Plate A.6 into Plate A.1. But it still is a valid Sudoku matrix. You also can interchange columns as long as you stay within the boundaries of one stack of three boxes. In Plate A.7, columns E and F have been interchanged, again producing a different, but valid, Sudoku matrix. But interchanging rows (or columns) between different boxes is not acceptable. Rows 3 and 4 have been interchanged in Plate A.8, with the result that the top six boxes all now have unacceptable duplications of digits. In short, altering only the symbols yields an unchanged Sudoku. Interchanging rows or columns within a set of boxes creates a different but acceptable Sudoku, but interchanging rows or columns across box boundaries destroys the Sudoku properties.

Plate A.1

| Col: | A | B | C | D | E | F | G | H | I |
|------|---|---|---|---|---|---|---|---|---|
| Row: | | | | | | | | | |
| 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 2 | 4 | 5 | 6 | 7 | 8 | 9 | 1 | 2 | 3 |
| 3 | 7 | 8 | 9 | 1 | 2 | 3 | 4 | 5 | 6 |
| 4 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 1 |
| 5 | 5 | 6 | 7 | 8 | 9 | 1 | 2 | 3 | 4 |
| 6 | 8 | 9 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 7 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 1 | 2 |
| 8 | 6 | 7 | 8 | 9 | 1 | 2 | 3 | 4 | 5 |
| 9 | 9 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Plate A.2

| Col: | A | B | C | D | E | F | G | H | I |
|------|---|---|---|---|---|---|---|---|---|
| Row: | | | | | | | | | |
| 1 | A | B | C | D | E | F | G | H | I |
| 2 | D | E | F | G | H | I | A | B | C |
| 3 | G | H | I | A | B | C | D | E | F |
| 4 | B | C | D | E | F | G | H | I | A |
| 5 | E | F | G | H | I | A | B | C | D |
| 6 | H | I | A | B | C | D | E | F | G |
| 7 | C | D | E | F | G | H | I | A | B |
| 8 | F | G | H | I | A | B | C | D | E |
| 9 | I | A | B | C | D | E | F | G | H |

Plate A.3

| Col: | A | B | C | D | E | F | G | H | I |
|------|----|----|----|----|----|----|----|----|----|
| Row: | | | | | | | | | |
| 1 | H | He | Li | Be | B | C | N | O | F |
| 2 | Be | B | C | N | O | F | H | He | Li |
| 3 | N | O | F | H | He | Li | Be | B | C |
| 4 | He | Li | Be | B | C | N | O | F | H |
| 5 | B | C | N | O | F | H | He | Li | Be |
| 6 | O | F | H | He | Li | Be | B | C | N |
| 7 | Li | Be | B | C | N | O | F | H | He |
| 8 | C | N | O | F | H | He | Li | Be | B |
| 9 | F | H | He | Li | Be | B | C | N | O |

Plate A.4

| Col: | A | B | C | D | E | F | G | H | I |
|------|----|----|----|----|----|----|----|----|----|
| Row: | | | | | | | | | |
| 1 | ! | @ | # | \$ | % | £ | & | * | ≈ |
| 2 | \$ | % | £ | & | * | ≈ | ! | @ | # |
| 3 | & | * | ≈ | ! | @ | # | \$ | % | £ |
| 4 | @ | # | \$ | % | £ | & | * | ≈ | ! |
| 5 | % | £ | & | * | ≈ | ! | @ | # | \$ |
| 6 | * | ≈ | ! | @ | # | \$ | % | £ | & |
| 7 | # | \$ | % | £ | & | * | ≈ | ! | @ |
| 8 | £ | & | * | ≈ | ! | @ | # | \$ | % |
| 9 | ≈ | ! | @ | # | \$ | % | £ | & | * |

Plate A.5

| Col: | A | B | C | D | E | F | G | H | I |
|------|---|---|---|---|---|---|---|---|---|
| Row: | | | | | | | | | |
| 1 | 8 | 3 | 1 | 6 | 4 | 9 | 7 | 2 | 5 |
| 2 | 6 | 4 | 9 | 7 | 2 | 5 | 8 | 3 | 1 |
| 3 | 7 | 2 | 5 | 8 | 3 | 1 | 6 | 4 | 9 |
| 4 | 3 | 1 | 6 | 4 | 9 | 7 | 2 | 5 | 8 |
| 5 | 4 | 9 | 7 | 2 | 5 | 8 | 3 | 1 | 6 |
| 6 | 2 | 5 | 8 | 3 | 1 | 6 | 4 | 9 | 7 |
| 7 | 1 | 6 | 4 | 9 | 7 | 2 | 5 | 8 | 3 |
| 8 | 9 | 7 | 2 | 5 | 8 | 3 | 1 | 6 | 4 |
| 9 | 5 | 8 | 3 | 1 | 6 | 4 | 9 | 7 | 2 |

Plate A.6

| Col: | A | B | C | D | E | F | G | H | I |
|------|---|---|---|---|---|---|---|---|---|
| Row: | | | | | | | | | |
| 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 2 | 7 | 8 | 9 | 1 | 2 | 3 | 4 | 5 | 6 |
| 3 | 4 | 5 | 6 | 7 | 8 | 9 | 1 | 2 | 3 |
| 4 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 1 |
| 5 | 5 | 6 | 7 | 8 | 9 | 1 | 2 | 3 | 4 |
| 6 | 8 | 9 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 7 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 1 | 2 |
| 8 | 6 | 7 | 8 | 9 | 1 | 2 | 3 | 4 | 5 |
| 9 | 9 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Plate A.7

| Col: | A | B | C | D | E | F | G | H | I |
|------|---|---|---|---|---|---|---|---|---|
| Row: | | | | | | | | | |
| 1 | 1 | 2 | 3 | 4 | 6 | 5 | 7 | 8 | 9 |
| 2 | 4 | 5 | 6 | 7 | 9 | 8 | 1 | 2 | 3 |
| 3 | 7 | 8 | 9 | 1 | 3 | 2 | 4 | 5 | 6 |
| 4 | 2 | 3 | 4 | 5 | 7 | 6 | 8 | 9 | 1 |
| 5 | 5 | 6 | 7 | 8 | 1 | 9 | 2 | 3 | 4 |
| 6 | 8 | 9 | 1 | 2 | 4 | 3 | 5 | 6 | 7 |
| 7 | 3 | 4 | 5 | 6 | 8 | 7 | 9 | 1 | 2 |
| 8 | 6 | 7 | 8 | 9 | 2 | 1 | 3 | 4 | 5 |
| 9 | 9 | 1 | 2 | 3 | 5 | 4 | 6 | 7 | 8 |

Plate A.8

| Col: | A | B | C | D | E | F | G | H | I |
|------|---|---|---|---|---|---|---|---|---|
| Row: | | | | | | | | | |
| 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 2 | 4 | 5 | 6 | 7 | 8 | 9 | 1 | 2 | 3 |
| 3 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 |
| 4 | 7 | 8 | 9 | 1 | 2 | 3 | 4 | 5 | 6 |
| 5 | 5 | 6 | 7 | 8 | 9 | 1 | 2 | 3 | 4 |
| 6 | 8 | 9 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 7 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 1 | 2 |
| 8 | 6 | 7 | 8 | 9 | 1 | 2 | 3 | 4 | 5 |
| 9 | 9 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |