

## How Excel Generates Random Numbers

In Excel 2003, an improved random number generator was implemented. Earlier versions of Excel used a pseudo-random-number-generation algorithm whose performance on standard tests of randomness was not sufficient to satisfy the demand of power users who might require the generation of a million or more random numbers. For the majority of users, the older pseudo-random-number generator was satisfactory.

The earlier algorithm used the following iterative method to calculate pseudo-random numbers:

The first random number:

$$r = \text{fractional part of } (9821 \times s + 0.211327)$$

where  $s = 0.5$ , and successive random numbers:

$r = \text{fractional part of } (9821 \times s + 0.211327)$

where  $s$  = the previous random number

In an effort to increase the "randomness," Microsoft later provided a patch that caused  $r$  to be determined from the system clock (which added a further degree of randomness to the numbers generated). But because these pseudo-random numbers are produced by a mathematical algorithm, if a long sequence of them is produced, eventually the sequence will repeat itself. Statistical tests on series of random numbers produced by the earlier version of RAND revealed that the cycle before numbers started repeating was unacceptably short, in the vicinity of one million.

In the improved random number generator used in Excel 2003, three sets of random numbers are generated. Three of these random numbers are summed, and the fractional part of the sum is used as the random number. By this procedure, it is stated that more than  $10^{13}$  numbers will be generated before the repetition begins.

The random-number algorithm in Excel 2003 was developed by B. A. Wichman and I. D. Hill ("Algorithm AS 183: An Efficient and Portable Pseudo-Random Number Generator," *Applied Statistics*, 31, 188–190, 1982; "Building a Random-Number Generator," *BYTE*, pp. 127–128, March 1987). This random number generator is also used in a software package that is provided by the U.S. Department of Health and Human Services. It has been shown to pass tests developed by NIST (National Institute of Standards and Technology).