# **Tutorial of Simulation using Excel Spreadsheet**

Using Excel, we can conduct simulation in two ways.

- 1. Conduct simple simulation in a spreadsheet.
- 2. Conduct complicated simulation using Visual Basic for Application (VBA) programming language.

This tutorial provides a minimum guide for a beginner to conduct simple simulation in a spreadsheet.

In Excel, we can use the built-in worksheet functions in a formula in a cell. Some basic functions commonly used in simulation are as follows.

1. Generate a random number (uniformly between 0 and 1):

=RAND()

2. IF function

## =IF(logical\_test,[value\_if\_true],[value\_if\_false])

checks a condition in its first argument, and if the condition is true returns the first value; otherwise it returns the second value.

- Example: =IF(RAND()<=0.5,0,1) returns 0 if the random number is smaller than 0.5; returns 1 otherwise.
- Example: =IF(A1<=0.5,0,IF(AND(A1>0.5,A1<=0.8),1,2)) returns 0 if A1<=0.5, 1 if 0.5<A1<=0.8, and 2 if A1>0.8.
- 3. Generate a uniformly distributed integer value in an interval:

#### =RANDBETWEEN(bottom,top)

4. Exponential distribution and normal distribution:

EXPON.DIST(x,lambda,cumulative), NORMDIST(x,mean,standard\_dev,cumulative)

If cumulative == "TRUE", returns the cdf; if cumulative == "FALSE", returns the pdf.

5. Inverse cdf of normal distribution:

# NORM.INV(probability,mean,standard\_dev)

Given a value for probability, NORM.INV seeks that value x such that NORM.DIST(x, mean, standard\_dev, TRUE) = probability.

- 6. There is no inverse cdf for exponential distribution. For some other distributions, like t distribution and binomial distribution, there exist pdf (pmf) / cdf function and inverse cdf function.
- 7. To generate a standard normal random variate:

#### NORM.INV(RAND(),0,1)

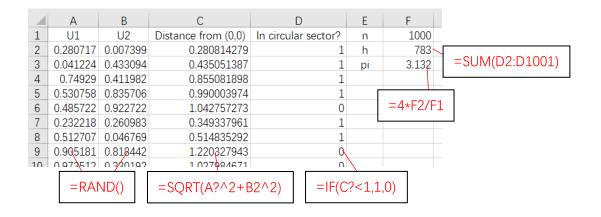
8. To generate an exponential random variate with rate lambda:

## =-1/lambda\*LOG(RAND(),EXP(1))

9. In a worksheet cell in Excel, we can also call a user-written VBA function. The user-written VBA functions can, in turn, call an internal VBA function such as Rnd().

Note: Neither the worksheet function RAND() nor the VB function Rnd() should be used in professional work; they both have known deficiencies.

# **Example 1**Monte Carlo Simulation: Estimate pi from Random Points



Note: "?" in formula represents the corresponding row number.

### Example 2

Discrete-Event System Simulation: M/M/1 Queue with  $\lambda = 0.6, \mu = 1$ 

$$L = \frac{\rho}{1-\rho} = \frac{0.6}{1-0.6} = 1.5$$
,  $L_Q = \frac{\rho^2}{1-\rho} = \frac{0.36}{1-0.6} = 0.9$ ,  $W = \frac{1}{\mu-\lambda} = \frac{1}{0.4} = 2.5$ ,  $W_Q = \frac{\rho}{\mu-\lambda} = \frac{0.6}{0.4} = 1.5$ .

