

# Practice of Basic Informatics

## [Week 05 Mini Lecture]

### -Simulation with a Spreadsheet-

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# What is Simulation?

- Investigating a real-life phenomenon, process, or problem using a model
  - Simulate a static state where the system is stationary
  - Simulate a **dynamic situation** where the system evolves over time
  - Simulate the situations with inclusion of **random factors**

# Simulation Modeling

- **Variables** that change their values over time
- **Rules** that describe the change
- **Initial values** of the variables
- Parameters
  - A parameter does not change its value during a particular simulation, e.g., interest rate, monthly repayment of debt, etc.
  - We can study how the behavior of the system changes with different parameter values

→ Study real examples in the textbook

# Value from Simulation Modeling

- In business (and life), “do overs” are not always possible
  - Simulations let you experiment with different decisions and see their outcomes
- Humans have a poor ability to assess odds in some situations
  - You can use repeated simulation “trials” to assess odds of various outcomes
- Companies typically use simulations to assess the **likelihood of outcomes** that may follow from different actions

# Creating a Simulation with a Spreadsheet

- Because you can simulate so many different kinds of situations, there is no one “recipe” to follow
- Makes it challenging, and creative (even fun?!)
- Simulations typically require bringing together lots of Spreadsheet (Excel) skills!
  - If you can do Excel simulations, then you are good at Spreadsheet Excel
  - Question 4 in Assignment 04 is a first step

# Simulation Modeling in Excel

- First get your model of the problem (finance/profit/cost/capacity/whatever) correct, before making certain inputs random
  - Visually separate your model on the Worksheet
- Then make the necessary inputs random
  - Refresh the Worksheet many times to see the random values change and check whether your model's calculations seem to behave properly
- Then add a Data Table to automate **many, many trials** of your model, collecting the output(s) you want
- Then add some summarizing statistics (e.g., average) based on the results you obtained in your Data Table

	A	B	C	D	E	F	G	H
1	# Luxury rooms	# Standard rooms		Nightly Overhead	Room units	Units per Std room	Units per Luxury room	
2	30	40		\$6,000.00	100	1	2	
3								
4								
5			Price	Cleaning cost				
6	Standard	\$ 99.00	\$ 12.50					
7	Luxury	\$ 160.00	\$ 25.00					
8								
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10022								
10023								
10024								

Model inputs

The model

Data Table (2 way)

Scenarios

# of luxury rooms to build

Summary statistics

Average #DIV/0! #DIV/0! #DIV/0! #DIV/0! #DIV/0! #DIV/0!

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# General Tips on Modeling in Excel

- Organize – keep your worksheet neat
- Be clear on how to do any given calculation on paper first
  - Then identify the corresponding Excel function, using Google search if you don't know the name of the Excel function
- Do not embed data values within formulas (**important!**)
  - Put data values in visible cells and reference that data
- Do not put too much logic in one cell
  - If it starts to get complicated, split the logic across more cells

# Two Dice Sum Game



- A traditional die is a cube, with each of its six faces showing a different number of dots (pips) from 1 to 6.
- Pick up a pair of dice and roll them. When they stop, two faces will be showing. The dice might show 1 and 3, or maybe 2 and 4. Roll them again and there is a good chance that a different pair of faces will show up.
- We say that the experimental result is not reproducible and that the results from the dice fluctuate.

# Two Dice Sum Game



- By rolling two dice, the sum of the scores on the two dice is an integer between 2 and 12.

<u>Sum</u>	<u>Pairs of dice</u>	<u>Probability</u>
2	1+1	$1/36 = 3\%$
3	1+2, 2+1	$2/36 = 6\%$
4	1+3, 2+2, 3+1	$3/36 = 8\%$
5	1+4, 2+3, 3+2, 4+1	$4/36 = 11\%$
6	1+5, 2+4, 3+3, 4+2, 5+1	$5/36 = 14\%$
7	1+6, 2+5, 3+4, 4+3, 5+2, 6+1	$6/36 = 17\%$
8	2+6, 3+5, 4+4, 5+3, 6+2	$5/36 = 14\%$
9	3+6, 4+5, 5+4, 6+3	$4/36 = 11\%$
10	4+6, 5+5, 6+4	$3/36 = 8\%$
11	5+6, 6+5	$2/36 = 6\%$
12	6+6	$1/36 = 3\%$

# Two Dice Sum Game



- We have calculate the theoretical probabilities for all possible sums.
- How will the probabilities for each integer to appear be different for different trial times?
- Simulation with a Spreadsheet by varying the trail times.
  - See how the experimental probabilities differs from the theoretical probabilities.

# Generating Random Numbers in Excel

- Excel has a RAND() function for generating “random” numbers
  - The numbers are really coming from a formula and hence are often called **pseudo-random**
  - =RAND() generates a number between 0 and 1, where all values are equally likely (the so-called Uniform distribution)
- =RANDBETWEEN(**low, high**) generates a pseudo-random integer # between **low** and **high**, where all #'s are equally likely
  - Throw a die by using the function RANDBETWEEN(1,6) in a Spreadsheet.

# (FYI) Generating Random Numbers in Excel

- We can use RAND() to generate #'s from other distributions
- To generate values from the Normal distribution
  - $=NORMINV(RAND(), \text{mean}, \text{standard\_deviation})$
- E.g.,  $=NORMINV(rand(), 10, 5)$ 
  - ...will generate a random number from a Normal distribution with mean 10 and std. dev. 5.

# (FYI) Other Simulation Examples: Another Dice Game

- We play a game against 2 opponents
  - 3 players (we are player 1)
- Each player rolls a die
- To win, a player needs to roll a # bigger than the other two dice values
  - If it's a tie, then the game is called a tie
- You want to simulate a play of the game and report whether you win, lose, or tie

# (FYI) Other Simulation Examples: Inventory Management

- Demand is uncertain, and you want to determine how many of your product to stock
  - Let's assume that demand is uniform between 50 and 150 units
  - Each units costs you \$6
  - Your price is \$10
  - If you end up with unsold units, you will have to “dump” them at \$2 salvage value
- Simulate one “play” of this game, where you stock a certain quantity and then see how much profit you make (given some random demand realization)