Statistics for Data Science - Hands-on 1
Random Number Generation

What are Random Numbers?

- **Random numbers** are sequences of numbers generated from a stochastic process, meaning their outcomes are unpredictable. In contrast, a deterministic process has outcomes that are fully predictable given initial conditions.
    - Example of a stochastic process: Rolling a die.
- A random number is selected using methods that give **equal probability** to all numbers within a specified distribution. To qualify as random, numbers must be **independent**, meaning there is no correlation between successive numbers.
- **Applications**: Random numbers are essential in various fields, including:
    - **Cryptography**: Used to generate cryptographic keys.
    - **Encryption algorithms**: Ensure secure communications.

Random Number Generators (RNGs)

A **Random Number Generator (RNG)** is a hardware device or software algorithm that produces numbers taken from a limited or unlimited distribution.
There are two main types:

1. **True Random Number Generators (TRNGs)**:
    - TRNGs rely on **unpredictable physical processes** to generate randomness.
    - These processes include atmospheric noise, thermal noise, radioactive decay, and other naturally occurring phenomena that are fundamentally random.
2. **Pseudo-Random Number Generators (PRNGs)**:
    - PRNGs use **mathematical algorithms** to generate a sequence of numbers that appear random.
    - Unlike true random numbers, PRNGs are not truly random because they depend on an initial **seed value**, making the sequence repeatable if the same seed is used.

Random Number Seed

A **random seed** is a number (or vector of numbers) used to initialize a PRNG. It acts as the starting point for generating a sequence of random numbers. Using the same seed ensures that the sequence of random numbers generated will be the same, which is useful for reproducibility in simulations.

Random Variates

A **random variate** is a variable generated from uniformly distributed pseudo random numbers, commonly used in simulations. These random variates serve as inputs to simulation models, allowing for the modelling of various stochastic processes.

Random Variate Generation

Random variate generation is critical in simulation modelling and analysis. Its objective is to produce observations that exhibit the same stochastic properties as a given random variable.

- To generate random variates, uniformly distributed random numbers are first produced within the interval **[0,1]**.
- From these uniformly distributed random numbers, other distributions can be derived using transformation techniques.

Methods for Random Variate Generation

There are several methods to generate random variates:

1. **Inverse Transform Method**:
    - This method transforms uniformly distributed random numbers to follow a desired distribution by applying the inverse of the cumulative distribution function (CDF).
2. **Acceptance-Rejection Method**:
    - This method generates candidate random variates from a simple distribution and accepts them based on a probability criterion.
    - This method has been discussed in the notebook.
3. **Composite Method**:
    - Combines multiple simple methods to generate random variates from complex distributions.
4. **Translations and Simple Transforms**:
    - Applies mathematical transformations to uniformly distributed random numbers to generate random variates from specific distributions.