Simulation:

A simulation is the imitation of the operation of a real-world process or system over time.

Modeling

Modeling is anything that represents something else,

Simulation and Modeling

Modeling and simulation is the use of models as a basis for simulations to develop data utilized for managerial or technical decision making.

simulation modeling is **computer based and uses algorithms and equations**.

System environment:

The changes occurring outside the system that affect the system is system environment

System:

Combination of **entities, attribute, activities** towards accomplishment of common goal

Entity: basic part of the system like class ma student teacher
Attribute: property of the entity like teacher ley deliberation of speech while teaching

- Continuous and discrete system
- Static dynamic system
- Stochastic deterministic system

Event/Activity: Instantaneous occurrence that might change the state of the system
Types: Endogenous(occur in the system), Exogenous(occur outside the system)

System simulation:

a set of techniques that uses computers to imitate the operations of various real-world tasks or processes through simulation

Open system:
System ko concept ma certain boundary hunxa like tyo boundary bhanda baira bata pani system lai effect garxa bhanay
affected by the exogenous events
Eg:- concert

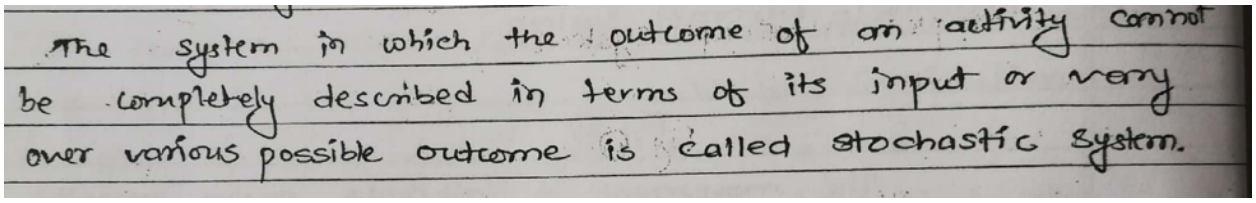
Closed system:
classroom bhitra xirxau ni then we are in closed system
Those system that is not affected by exogenous events

Continuous system
Rate of change of system with time
the state variables change in a continuous way, and not abruptly from one state to another (infinite number of states)
dx/dt

Discrete system
System in which state variable changes in the discrete interval of time
the state variables change only at a countable number of points in time.
These points in time are the ones at which the event occurs/change in state
For eg: banking system

Stochastic system:

The system which does not always produce the same output for a given input.



Deterministic system:

Those systems that will always produce the same output from a given starting condition or initial state.
Eg: chemical reaction,

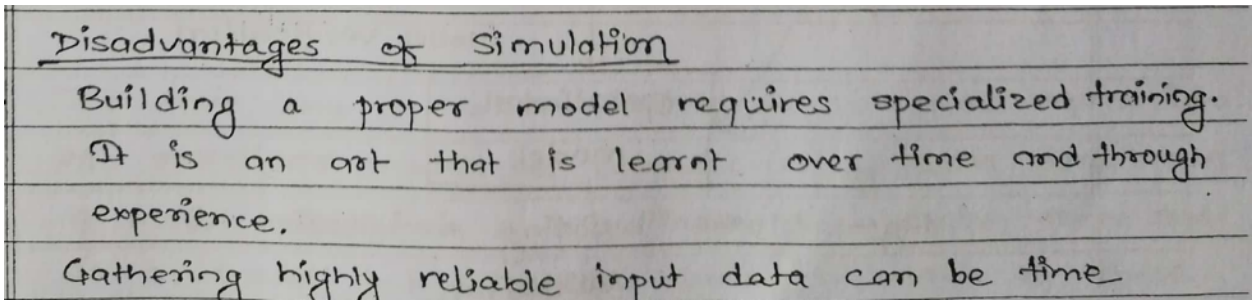
Use of simulation:

- solves real-world problems safely and efficiently
- scientific discovery,
- to test designs for safety, to save money,
- to create physics for movies and video games

Advantages of Simulation

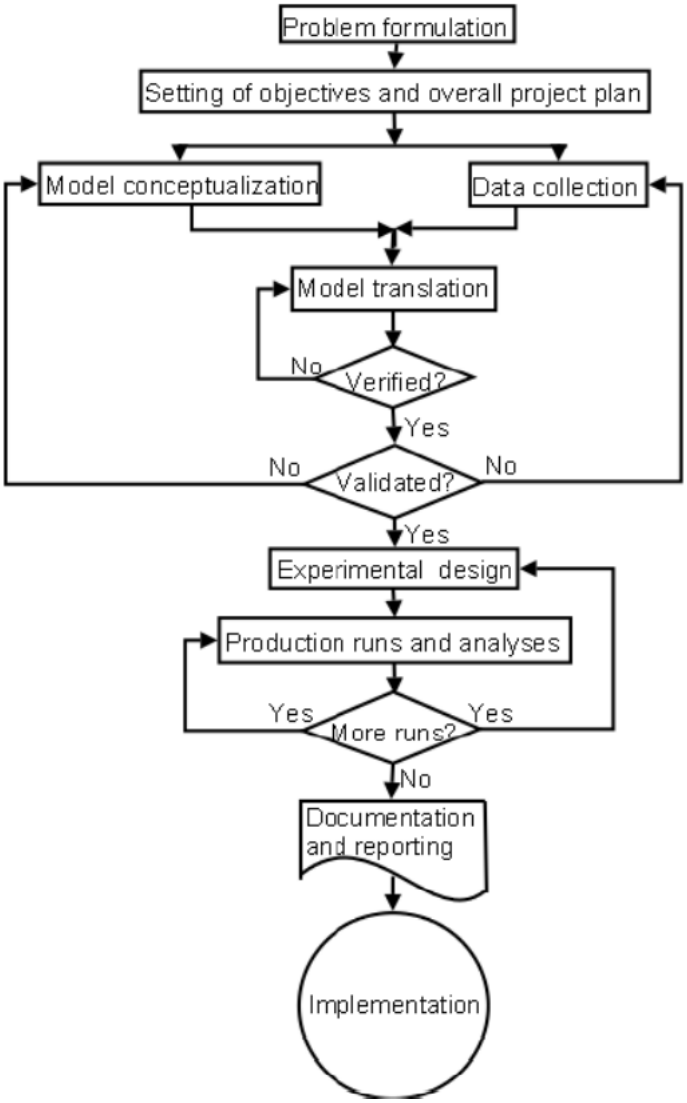
- Test new design without assigning resources for its implementation
- Time can be compressed or expanded
- Experiment with new and unfamiliar situations

Disadvantage of simulation


Disadvantages of Simulation
Building a proper model requires specialized training. It is an art that is learnt over time and through experience.
Gathering highly reliable input data can be time

- Requires specialized training
- Analytical simulations are possible
- Time consuming

Steps in simulation:



Physical model:

The model that is represented in the form of comparison.
Eg; DNA molecule, Architecture model of house

Mathematical model:

When we represent in the form of mathematical form

y=mx+c Eg: Equation of planet revolution

Static and dynamic model:

Equilibrium condition ma huney **static**

Continuous change bhairako bela ma **dynamic**

Validation vs verification

Verification	Validation
• It is concerned with building model right. • It is utilized with the comparison of the conceptual model to the computer representation that implements the conception • It does *not* involve executing • It comes before validation	• It deals with the building right model • It is utilized to determine that model is an accurate representation of real system • it always involves executing • It comes after verification

Monte-carlo simulation: (Accuracy check garnay model)

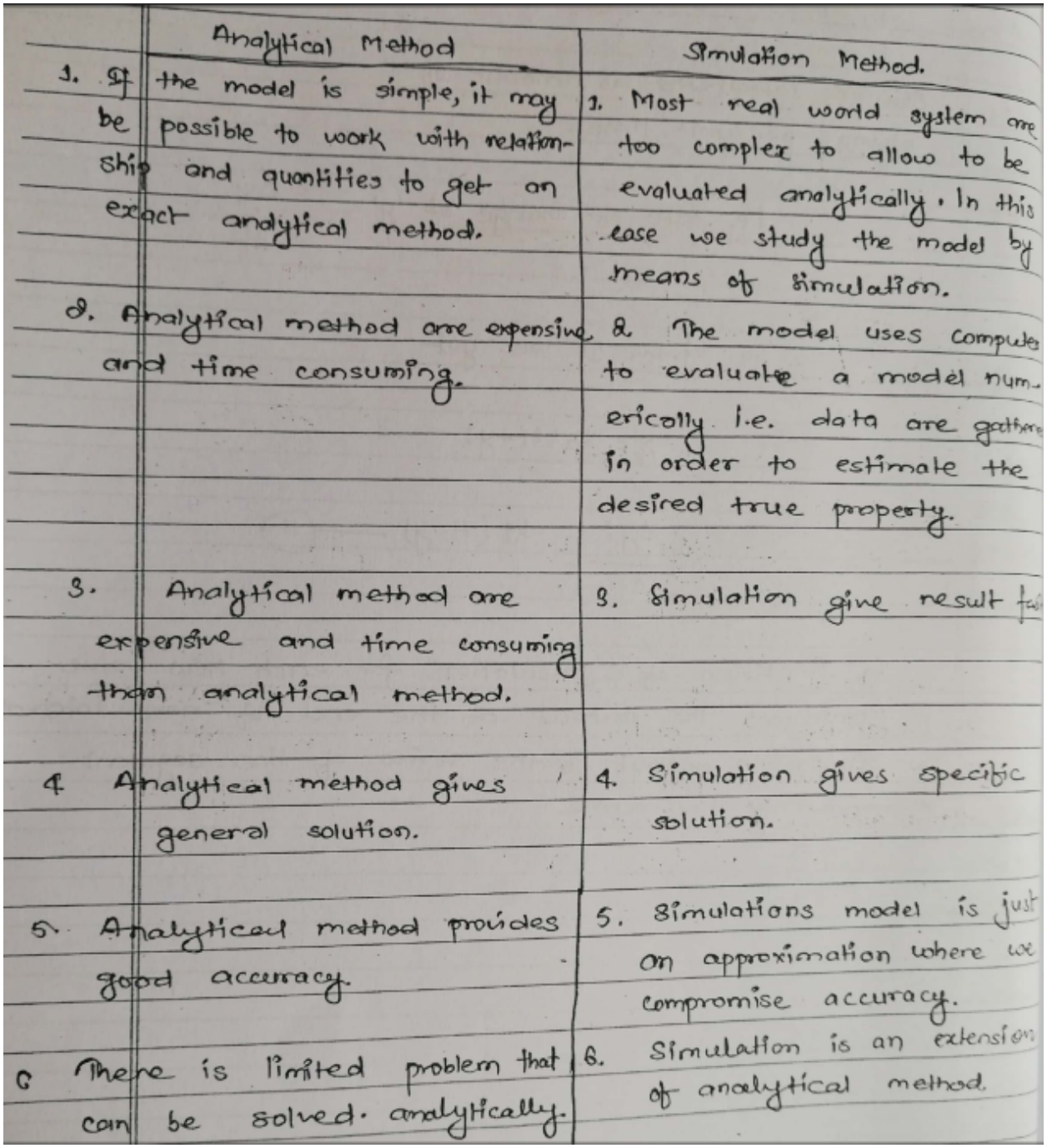
- **We use random variable to predict the probability of different outcomes**
- To estimate the possible outcomes of an uncertain event.

Monte Carlo simulations are used to model the probability of different outcomes in a process that cannot easily be predicted due to the intervention of random variables

Eg: Dart hitting game

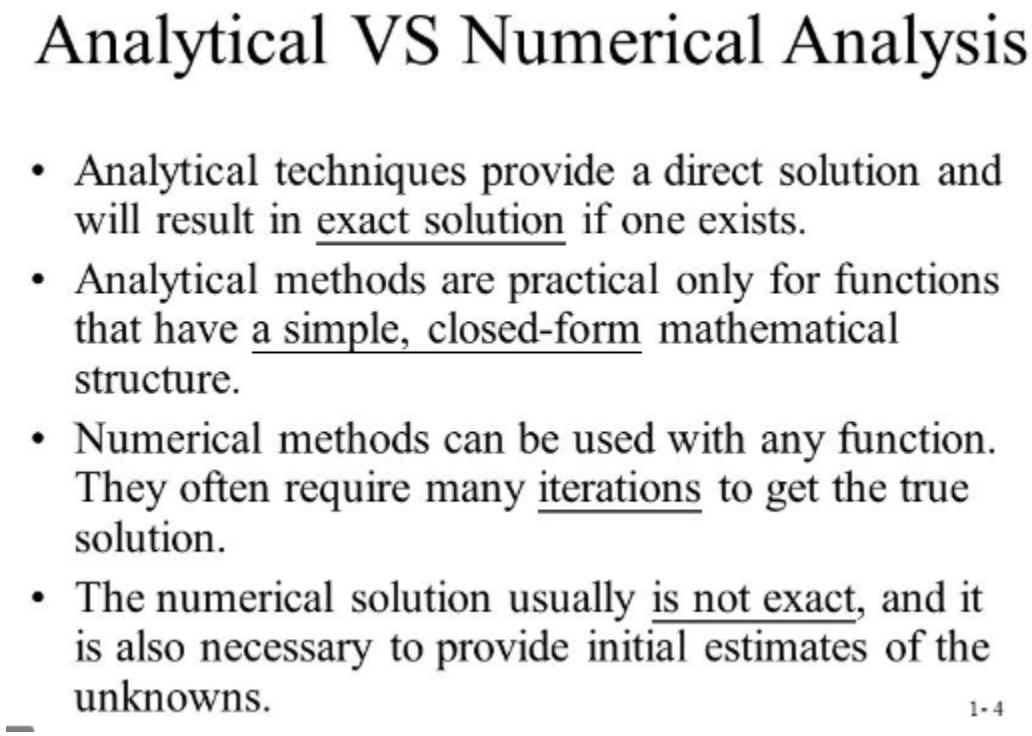
$$\frac{n}{N} = \frac{\int_a^b f(x)dx}{c(b-a)}$$

Simulation vs analytical



	Analytical Method	Simulation Method.
1.	If the model is simple, it may be possible to work with relationship and quantities to get an exact analytical method.	1. Most real world system are too complex to allow to be evaluated analytically. In this case we study the model by means of simulation.
2.	Analytical method are expensive and time consuming.	2. The model uses computer to evaluate a model numerically i.e. data are gathered in order to estimate the desired true property.
3.	Analytical method are expensive and time consuming than analytical method.	3. Simulation give result for
4	Analytical method gives general solution.	4. Simulation gives specific solution.
5.	Analytical method provides good accuracy.	5. Simulations model is just an approximation where we compromise accuracy.
6	There is limited problem that can be solved analytically.	6. Simulation is an extension of analytical method.

Analytical vs numerical



Simulated clock:

A variable giving current value of the simulated time.

Distributed model vs cobweb models

Distributed lag models- A model of time series data in which a regression equation is used to predict current values of **dependent variables based on both current and past values** of this explanatory variable. Eg: Census data

Cobweb models-is **an economic model that** explains why prices might be subject to periodic fluctuations in certain types of markets.

Application areas: Agricultural household

Types of simulation

- Real time simulation: that can execute at the same rate as actual "wall clock" time.

- System simulation: set of techniques that uses computers to imitate the operations of various real-world tasks or processes through simulation

Predator Prey model

Contain a pair of first-order nonlinear differential equations, frequently used to **describe the dynamics of biological systems in which two species interact, one as a predator and the other as prey**.

1. Predator population low $\Longrightarrow$ prey grows
2. High prey population $\Longrightarrow$ more food
   $\Longrightarrow$ predator poplulation increases
3. High predator population eats prey
   $\Longrightarrow$ prey population decreases
4. Low prey population $\Longrightarrow$ less food
   $\Longrightarrow$ predators decrease: back to 1

Hybrid simulation:

When an analog and digital computer are combined to provide simulation .
Eg: wind tunnel testing of aerodynamics of a car or a plane.

CSSL: (Computer System Simulation Language)

Very high-level programming language which facilitates modeling and simulation of the system characterized by the equations.

Markov chain:

A Markov chain is a stochastic model describing a sequence of possible events in which the **probability of each event depends only on the state attained in the previous event.** Eg: Random walk problem, board games, stock market.

Application:

- Market research
- Markov text generators
- Asset pricing and other financial prediction
- Customer journey prediction
- Population genetics
- Algorithmic composition
- Page ranks

Key features:

- The outcome of each experiment is one of a set of discrete states.
- The outcome of the experiment depends on the present state and not any past state.

Reneging

Sometimes, the entity may leave the queue even before being served.

Balking

If an entity refuses to join the queue (because the queue is relatively long)

Polling

If there are multiple lines i.e. queues but a single server, the entities are selected by the process of polling

Traffic intensity (u):

Let T be mean arrival time, T s be mean service time, λ be arrival rate, and μ be service rate then;

The ratio of mean service time to the mean inter-arrival time is called the traffic intensity (u)

$u = T_s / T_a$

Server utilization

Traffic intensity per server

$$\rho = \lambda / \mu$$

- Probability that the particular server is busy
- Approximately the fraction of time that each server is in use

Bootstrapping:-

Bootstrapping usually refers to a **self-starting** process that is supposed to **continue or grow** without external input.

Multi server queue:

Queue consisting of **multiple servers** and a **common queue** for all items.

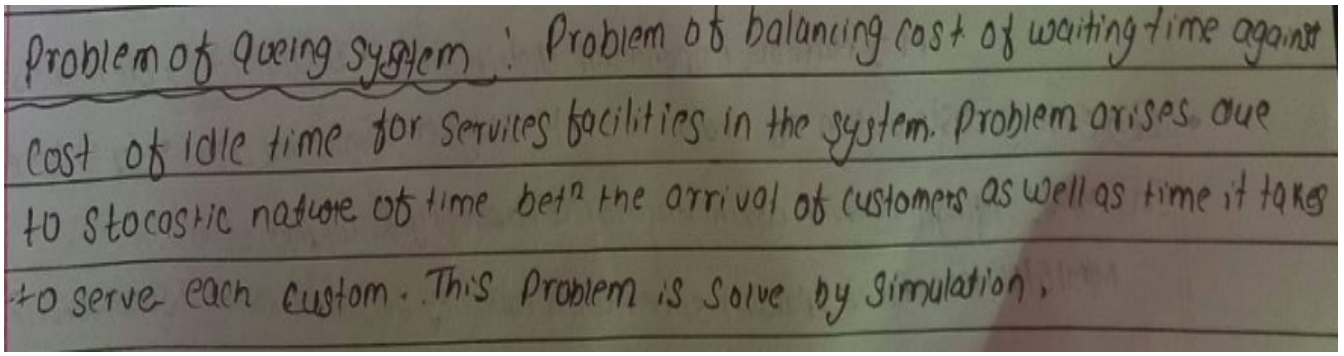
Queuing Systems:

The combination of all entities in a system being served and being waiting for a service.
Describing behaviour of Queuing system is **queuing model**

Characteristics:

- Determine how task in the system
- Determine task processing time / Service Time
- Total no. of the server available to process the task
- Storage capacity, buffer finite infinite

Problem:



Elements:

- FIFO (First In First Out) also called FCFS (First Come First Serve) - orderly queue.
- LIFO (Last In First Out) also called LCFS (Last Come First Serve) - stack.
- SIRO (Serve In Random Order).
- Priority Queue, that may be viewed as a number of queues for various priorities.

General Purpose Simulation System (GPSS)

is a discrete time simulation general-purpose programming language, where a simulation clock advances in discrete steps.

GPSS entities

_____Transactions, block, function, matrix, storage, queue, table, variable

GPSS commands

_____Clear, Continue, exit, Halt, see in pdf page 301

GPSS Blocks:(48 blocks)

1. **ADVANCE**:Block delays the progress of a Transaction for a specified amount of simulated time
2. **ASSIGN** :Blocks are used to place or modify a value in a Transaction Parameter.
3. **ENTER** :When a Transaction attempts to enter an ENTER Block, it either takes or waits for a specified number of storage units.
4. **GATE:** Block alters Transaction flow based on the state of an entity.
5. **GENERATE:** Block creates Transactions for future entry into the simulation.
6. **LEAVE**: Block increases the accessible storage units at a Storage Entity.
7. **LINK** :Block controls the placement of the Active Transaction on the User Chain of a Userchain Entity.
8. **LOGIC:** Block changes the state of a Logic switch entity.
9. **MARK:** Block places an absolute clock time stamp into the Active Transaction or into its Parameter.
10. **PRIORITY:** Block sets the priority of the Active Transaction.

    PRIORITY A,B

11. **RELEASE:** Block releases ownership of a Facility, or removes a preempted Transaction from contention for a Facility.
12. **SAVEVALUE:** Block changes the value of a Savevalue Entity.
13. **SEIZE:** When the Active Transaction attempts to enter a SEIZE Block, it waits for or acquires ownership of a Facility Entity.
14. **TABULATE:** Block triggers the collection of a data item in a Table Entity **TABULATE A,B**
15. **TERMINATE:** A TERMINATE Block removes the Active Transaction from the simulation and optionally reduces the Termination Count.
16. **TEST:** Block compares values, normally SNAs, and controls the destination of the Active Transaction based on the result of the comparison. **TEST O A,B,C**
17. **TRANSFER:** Block causes the Active Transaction to jump to a new Block location
18. **UNLINK:** An UNLINK Block removes Transactions from the User Chain of a Userchain Entity. **UNLINK O A,B,C,D,E,F**

GPSS control statement:

CLEAR:
CLEAR A CLEAR Command returns the simulation to the unused state. **CLEAR A**

END: which can terminate a Session

FUNCTION:
A FUNCTION Command defines the rules for a table lookup.

NAME FUNCTION A,B

INITIAL:
An INITIAL Command initializes a Matrix Entity, a Logicswitch Entity, Savevalue Entity, or an element of a Matrix Entity**. INITIAL A,B**

RESET:
A RESET Command marks the beginning of a measurement period.

RESET

START:
A START Command begins a simulation. **START A,B,C,D**

STORAGE:
A STORAGE Command defines a Storage Entity.

NAME STORAGE A

name of storage must start with 3 alphabets.

TABLE:
A TABLE Command initializes a frequency distribution table. **NAME TABLE A,B,C,D**

Entities :

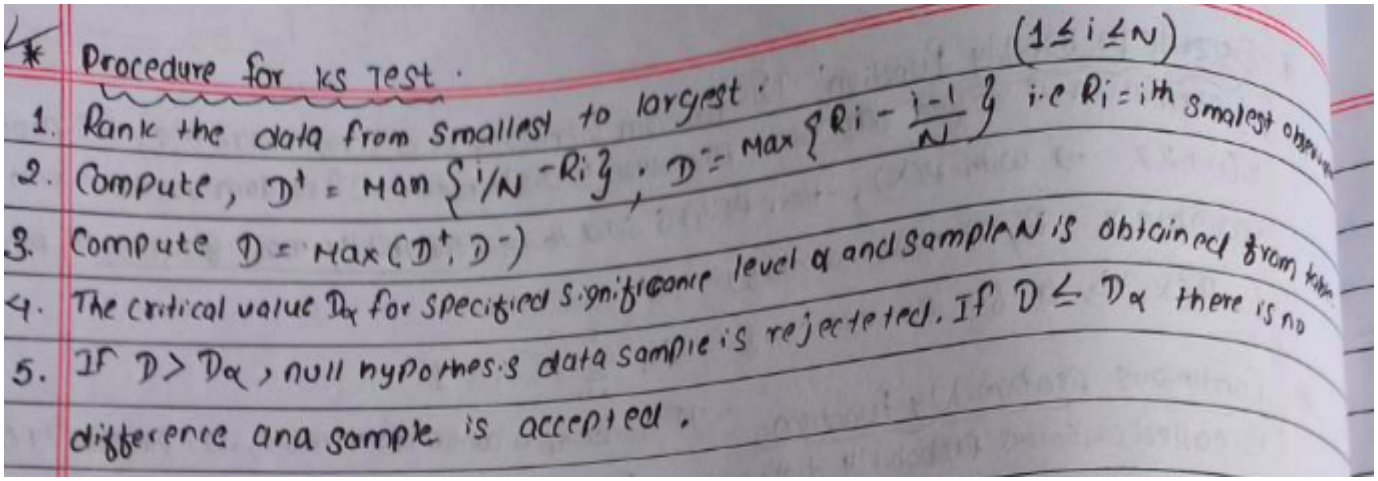
- **Transaction** entities: GENERATE, SPLIT, TRANSFER, TERMINATE ..
- **Facilities** entities: SEIZE, RELEASE ..
- **Queue** entities: QUEUE, DEPART
- **Storage** entities: ENTER, LEAVE

Chi-square test:

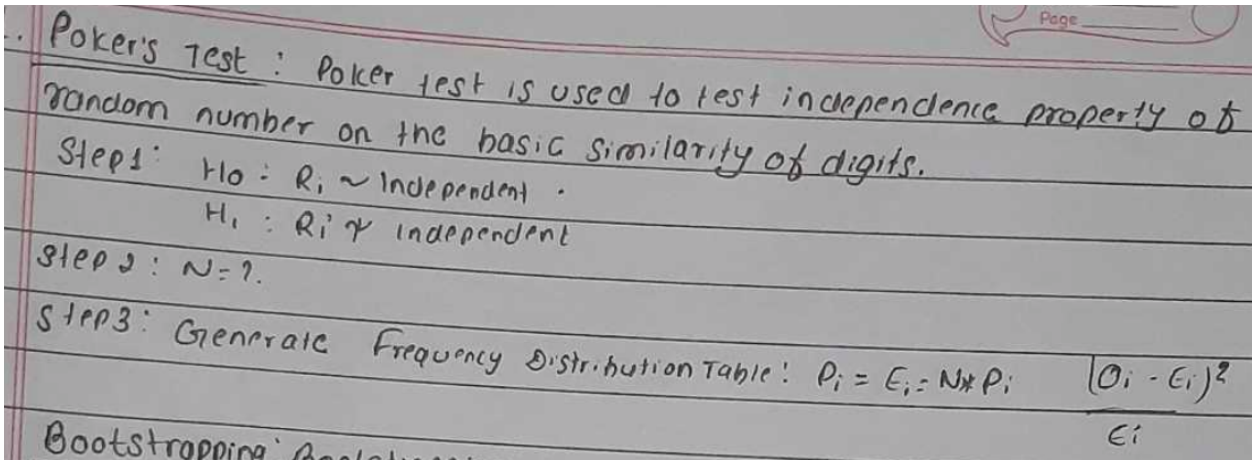
data analysis on the basis of observations of a random set of variables.

$$\chi_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

KS-test:



POKER test:


Poker's Test : Poker test is used to test independence property of random number on the basic similarity of digits.
Step1: Ho : R_i ~ Independent .
H_1 : R_i ⊁ Independent
Step 2 : N = ?.
Step3: Generate Frequency Distribution Table : $P_i = E_i = N * P_i$ $\frac{(O_i - E_i)^2}{E_i}$
Bootstrapping

Gpss vs simscript

Simscript event oriented ● General purpose simulation language ● It supports object oriented simulation development ● It can be used in broad range of the simulation areas such as:- telecommunication, flight formation	**Gpss(general purpose simulation system)** transaction flow oriented ● Earliest discrete simulation language ● It is designed especially for non programmer ● It doesn't write the program in the same sense as simscript ● It uses a block-structuring notation to build models.

Simscript

It is a free form simulation language which **reduces the time needed to program simulations of even moderate complexity and provides increased flexibility**

kendall notation of queuing system

is the **standard system used to describe and classify a queueing node When the final three parameters are not specified**

Uses of differential equation

- to calculate the movement or flow of electricity
- to explain thermodynamics concepts
- to calculate motion of an object to and fro like a pendulum

Gap test

The **gap test** is used to determine the significance of the interval between recurrence of the same digit.

Objective

- to evaluate differences
- find out what caused difference

Time advance mechanism / simulation time

_____Mechanism to simulate time from one value to another. Simulation clock gives current value

- **Next event time advance mechanism (event oriented)**
  Determines time of occurrence of future event from event list
- **Fixed event time advance mechanism (interval oriented)**
  In this approach the simulation clock advances with increment of exactly Δt time unit

m/m/1 queueing model

represents the queue length in a system having a single server, where arrivals are determined by a Poisson process and job service times have an exponential distribution

Components of analog computer

resistors, capacitors, variable voltage and current sources, an accurate timer, and accurate readout instrumentation

Call system:

Lost call system:

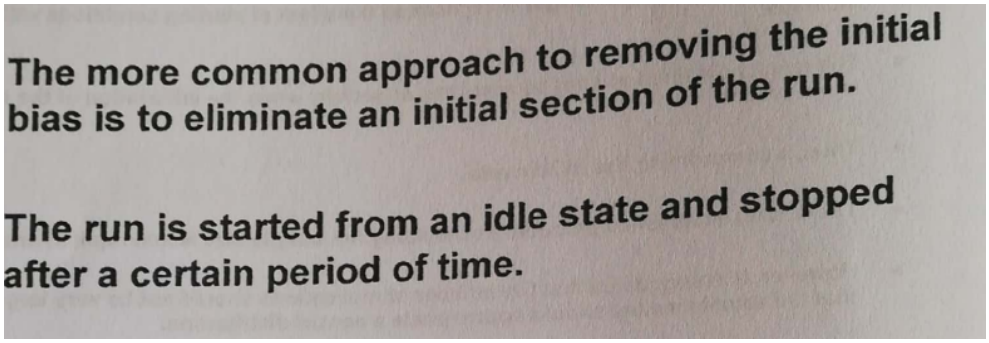
the call gets lost when it does not find a line to connect that call .the call is immediately abandoned(blocked).

Delay CALL:

When a call arrives at an automatic switching device and no of channel & facility is immediately available to process the call.

Elimination of the initial bias:

- System representative state rather than the empty state.
- First part can be ignored



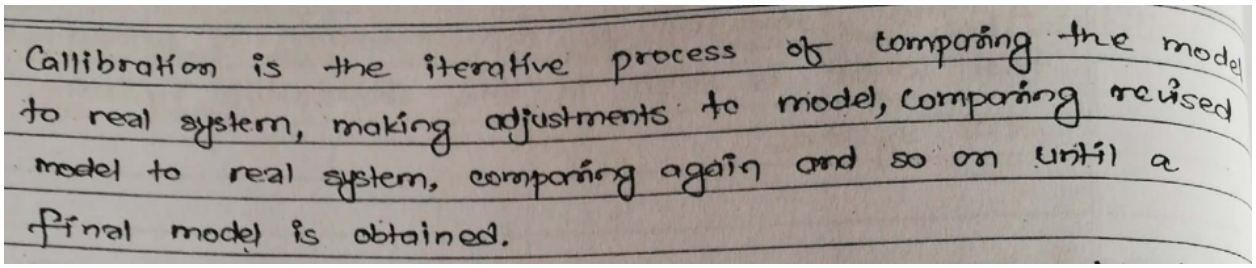
Random variable:

Value with uncertain

Properties of random number:

- uniformity, i.e. they are equally probable everywhere
- independence, i.e. the current value of a random variable has no relation with the previous values
- Should be replicable

Calibration:


Callibration is the iterative process of comparing the model to real system, making adjustments to model, comparing revised model to real system, comparing again and so on until a final model is obtained.

Calibration of model:

model's predictive uncertainty will only be reduced by calibration