NJ

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UNIT-1

Introduction to Simulation:

⊛. System:

System is a simplified representation of selected components with specified boundries and predefined time characteristics. It generally indicates a real world entity over space and time in generalized and specified form. Each system has a time constraint that defines the time over which the system may change its state.

System concept terms: (OR Components of System:)

i) State → A variable characterizing an attribute in the system such as number of jobs waiting for processing is called state.

ii) Activity/Event → An occurance at a point in time which may change the state of the system.
  Endogeneous activities → activities occuring within the system.
  Exogeneous activities → activities occuring in the environment.

iii) Entity → An object that passes through the system is known as entity.

iv) Queue → Any place where entities are waiting for something to happen for any reason, is called queue.

v) Scheduling → The act of assigning a new future event to an existing event.

vi) Random variable → It is a quantity that is uncertain.

⊛. System Environment:

The changes occuring outside the system that affect the system is system environment. Defining a system boundary is an important step.

→ Small system boundary may not include necessary components.

→ Larger system boundary may have high degree of error propagation and management difficulties.

Closed system → That is not affected by the exogeneous event.

Open system → Affected by the exogeneous events.

⊛. Discrete System:

Discrete system is one in which the state variable changes only at a discrete set of time. For example: Banking system in which number of customers arrive or service provided to customer. The figure below shows how the number of customer changes only at a discrete points in time.

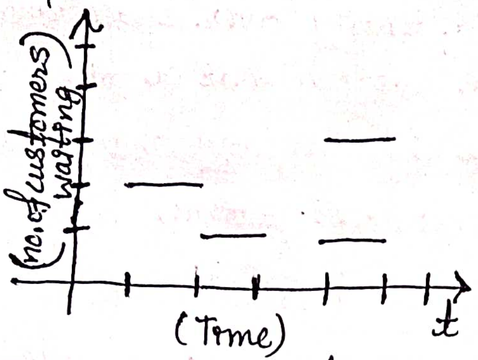

Fig: Discrete system.

⊛. Continious System:

Continious system is one in which the state variables change continiously over time. For Example: During winter season level of water decreases gradually and during rainy season level of water increases gradually. The change in water level is continious. The figure below shows the change of water level over time.

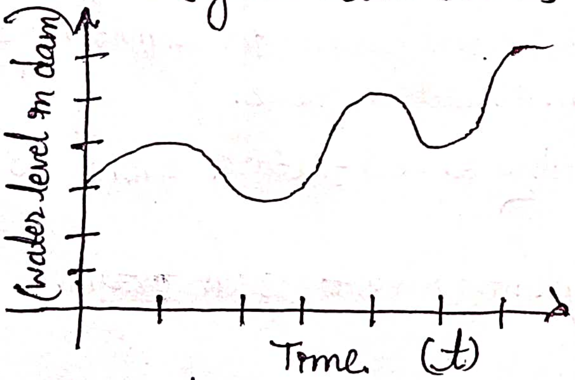

Fig: Continious System

⊛. System Modeling:

A model is defined as the representation of a system for the purpose of studying the system. It is necessary to consider only those aspect of the system that affect the problem under investigation. These aspects are represented in a model, and by definition it is a simplification of a system. There is no unique model of a system. Different models of the system will be produced by different system analysist who are interested in different aspects of the system.

The task of deriving a model of a system may be broadly divided in two subtask:

i) <u>Establishing model parameter</u> → It determines system boundaries and identifies the entities, attributes, activities and events of a system.

ii) <u>Supplying data</u> → It provides value content and attribute and defines relationship involved in the activities.

Types of Model: [Imp]

i) <u>Physical model:</u> In this model system attributes are represented by physical measures such as voltage. The system activities are represented by physical laws. Physical models are of two types, static and dynamic.

<u>Static physical model</u> → Static physical model is a scaled down model of a system which does not change with time. An architect before constructing a building makes a scaled down model of the building, which reflects all it's rooms, outer design and other important features. This is an example of static physical model.

<u>Dynamic physical model</u> → Dynamic physical model is one which change with time or which are function of time. In wind tunnel, small aircraft models (static models) are kept and air is blown over them with different velocities and pressure profiles are measured with the help of transducers embedded in the model. Here wind velocity changes with time is an example of dynamic physical model.

Read about dynamic mathematical model and static mathematical model aslo from model set soln!

ii) <u>Mathematical model:</u> It uses symbolic notation and mathematical equation to represent system. The system attributes are represented by variables and the activities are represented by mathematical function. Example: $f(x) = mx + c$ is a mathematical model of a line.

iii) <u>Static model:</u> Static models can only show the values that the system attributes value does not change over time. Example: Graphs are used to model the various system based on network.

iv) **Dynamic model:** Dynamic model follow the changes over time that result from system activities. The mechanical and electrical systems are the example of dynamic system.

v) **Deterministic model:** It contains no random variable but have a known set of inputs which will result in a unique set of outputs.
Example:- Arrival of patients to the Dentist at the scheduled appointment time.

vi) **Stochastic model:** It contains one or more random variable as inputs. Random inputs leads to random outputs. Example: Simulation of a bank involves random service times.

⊛. Use of Differential and Partial differential equations in Modeling:

The equation that consists higher order derivatives of the dependent variable is known as differential equations. The differential equation is said to be linear if any of the dependent variable and its derivatives have power of one and are multiplied by the constant.
E.g. $Mx'' + Dx' + Kx = K\,F(t)$

where, M, D and K are constants & $F(t)$ is the input to the system depending upon the independent variable t; x'' and x' are second and first order derivatives of dependent variable x.
The differential equation is said to be non-linear if the dependent variable or any of its derivatives are raised to a power or are combined in other way like multiplication.

The differential equation is said to be partial if more than one independent variables occur in a different equation.
Example: Equation of flow of heat in three dimensional body. It consists of four independent variables (three dimensions and time) and one dependent variable (temperature).

Necessity of differential equations:

→ Most physical and chemical process occuring in the nature involves rate of change, which requires differential equations to provide mathematical model.
→ It can be used to understand general effects of growth trends as differential equations can represent a growth rate.

⊛. Advantages of Simulation: [Imp]

→ New designs can be tested without acquiring resources.
→ New procedure or rules can be explored without hampering the ongoing real time system operations.
→ Insights can be obtained about the variable interaction and their credit for system performance.
→ It provides better understanding of the operation of the system.
→ Insight can be obtained about the interaction of variables.
→ The hypotheses about certain phenomena can be tested for feasibility.

⊛. Disadvantages of Simulation: [Imp]

→ Model building requires special training.
→ Simulation results may be difficult to interpret.
→ Simulation modeling and analysis can be time consuming and expensive.
→ Simulation is used in some cases when an analytical solution is possible or even preferable.

⊛. Application areas of Simulation:

i) Manufacturing Applications:
→ Analysis of electronics assembly operations.
→ Optimization of cycle time and utilization in semiconductor test manufacturing.
→ ~~Ananly~~ Analysis of storage and retrival strategis in a warehouse.

ii) Construction Engineering :
→ Construction of a dam embankment.
→ Activity scheduling in a dynamic, multi-project setting.
→ Investigation of the structural steel erection process.

iii) Military Applications:
→ Modeling military requirements for non-war fighting operations.
→ Multi trajectory performance for varying scenario sizes.
→ Design and test of an intelligent controllers.

iv) Human Systems:-
→ Modeling human performance in complex systems.
→ Studying the human element in our traffic control.

v) **Business Process Simulation:**
→ Product development program planning.
→ Reconcillation of business and system modeling.

⊗. Phases in Simulation Study:- [Imp]

Steps in simulation study:

1. Problem formulation → Clearly state the problem.
2. Setting of objectives and overall project plan → How we should approach the problem.
3. Model conceptualization → Establish a reasonable model.
4. Data collection → Collect the data necessary to run the simulation such as arrival rate, arrival process, service rate etc.
5. Model translation → Convert a model into a programming language.
6. Verification → Verify the model by checking if the program works properly.
7. Validation → Check if the system accurately represent the real system.
8. Experimental design → How many runs? For how long? What kind of input variations?
9. Production runs and analysis → Actual running the simulation, collect and analyze the output.
10. Repeatation → Repeat the experiments if necessary.
11. Document and report → Document and report the results.
12. Implementation → Implement the simulated system in the real world if the simulation results show that its advantageous to implement the new system or policy.

Phases:

I Phase:
→ Consists of step 1 and 2.
→ It is a period of discovery/orientation.
→ The analyst may have to restart process if it is not fine-tuned.
→ Recalibrations and clarifications may occur.

II Phase:
→ Consists of step 3, 4, 5, 6 and 7.
→ A continuing interplay is required among the steps.
→ Exclusion of model user results in implications during implementation.

III Phase:

→ Consists of steps 8, 9 and 10.

→ The output variables are estimates that contain random error and therefore proper statistical analysis is required.

IV Phase:

→ Consists of steps 11 and 12.

→ Successful implementation depends on the involvement of user and every steps successful completion.

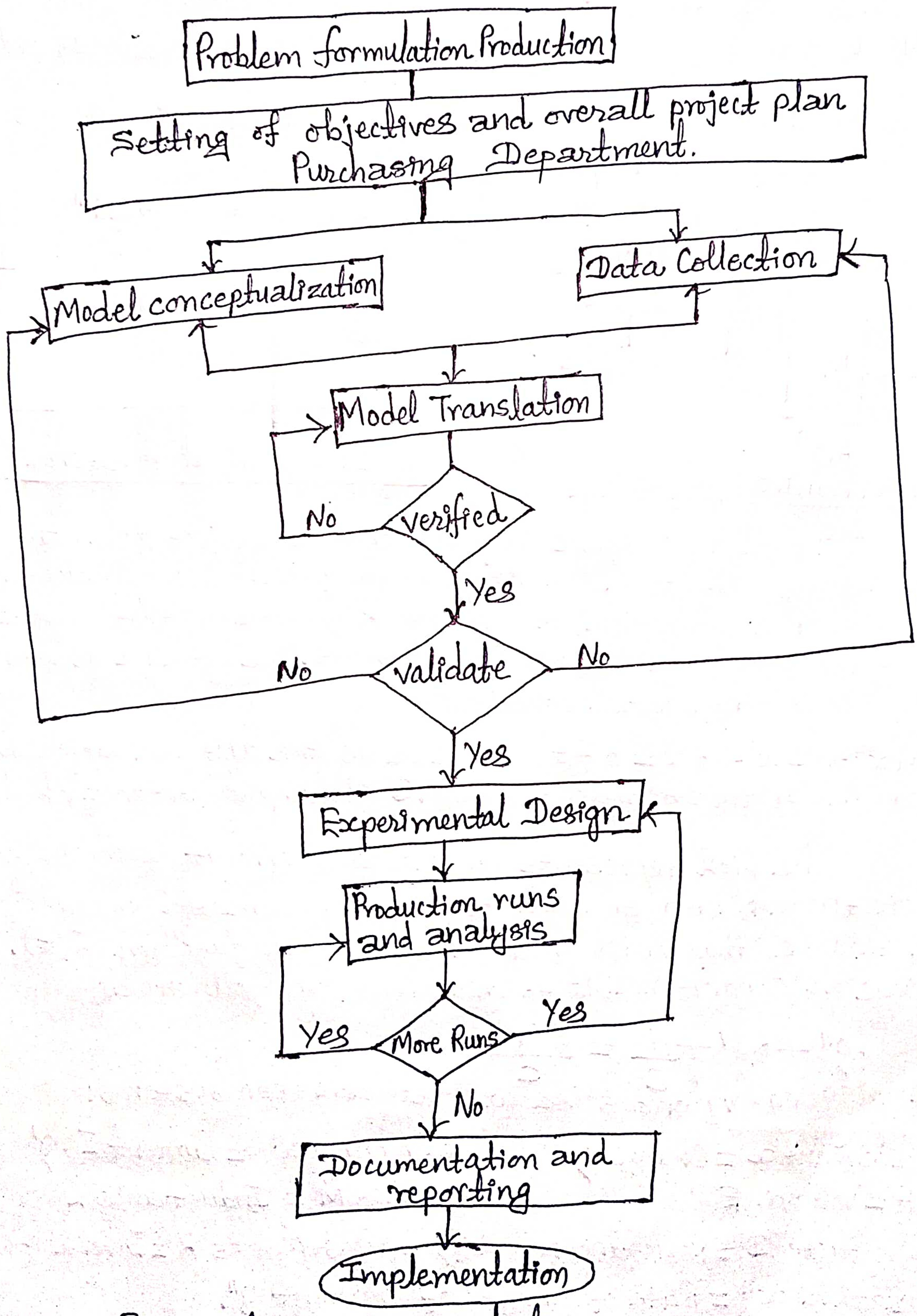

Fig: Steps in simulation.

[Imp] Q. Define Simulation. Explain the dynamic physical model with suitable example (OR with suitable diagrams and expressions).

Ans: Simulation is the imitation of the operation of a real-world process or system over time. Simulation involves the generation of an artificial history of the system, and the observation of that artificial history to draw inferences concerning the operating characteristics of the real system that is represented.

Dynamic Physical Model:

OR this may be asked as analogy betw^n Mechanical and electrical system.

Note: ⇒ First write theory of dynamic physical model, same that we wrote in types of model already then proceed as follows:-

⇒ To illustrate this type of physical model consider two systems as shown in the figures below:

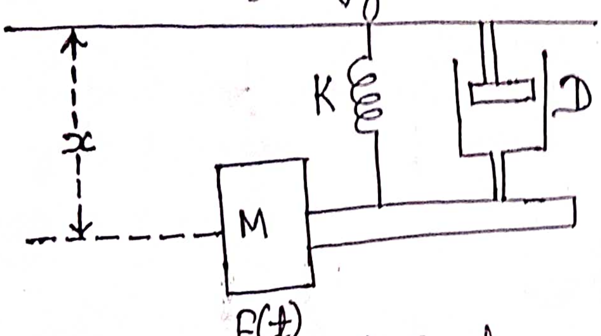

Fig1: Mechanical System

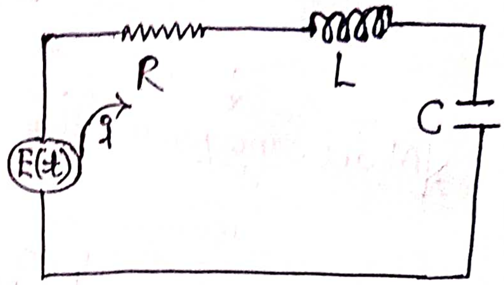

Fig2: Electrical System

The fig1 represents a mass, that is subject to an applied force F(t) varying with time, a spring whose force is proportional to its extension or contraction, and a shock absorber that exerts damping force proportional to velocity of mass. The system is described by the following differential equation:

$Mx'' + Dx' + Kx = KF(t)$ where, x is the distance moved, M is the mass and K is the stiffness of spring. D is damping factor of shock absorber.

The Fig2 represents an electrical circuit with an inductance L, a resistance R, and a capacitance C, connected in series with a voltage source that varies in time according to function E(t). If q is the charge on capacitance, it is described by following differential equation:

$$Lq'' + Rq' + \frac{q}{C} = \frac{E(t)}{C}$$

The following equivalences occur between two systems:

a) Displacement x = Charge q
b) Velocity x' = Current I, q'
c) Force F = Voltage E
d) Mass M = Inductance L
e) Damping Factor D = Resistance R
f) Spring stiffness K = Inverse of capacitance $\frac{1}{C}$
g) Acceleration x'' = Rate of charge of current q''.

⇒ The mechanical system and the electrical system are <u>analogs</u> of eachother, and the performance of either can be studied with the other.