Unit I

# INTRODUCTION TO MODELING AND SIMULATION

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# System Concept

- A System is defined as a group of components working together to form a single unit for achieving a common goal.
- A **system** is an aggregation of objects joined together to accomplish some task.
- Eg: A factory system that makes and assembles parts into product can be taken as a system as shown in figure below

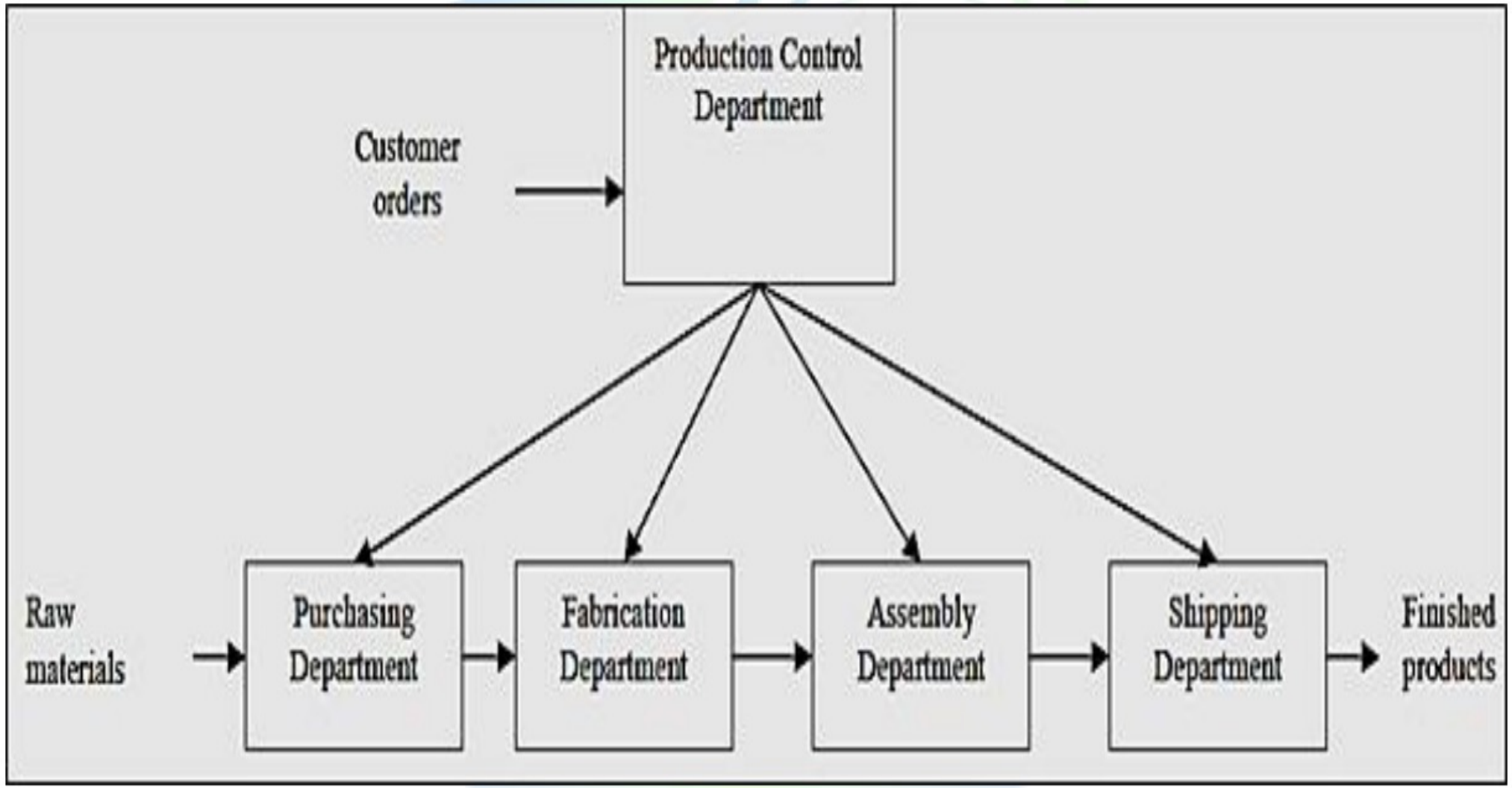



*Fig: A Factory System*

# Two major components of above system are:

- Fabrication Dept: For making parts
- Assembling Dept: For producing the products.

However some other components also exists in the above system like:

- **Purchasing Dept:** for maintaining a supply of parts.
- **Shipping Dept:** For dispatching the finished product.
- **Production control Dept:** For receiving orders and assigning tasks to other department.

# Components of System

- Entity
- Attributes
- Activity
- Event
- State of System

# Entity

- It is an object to interest in the system.
- Example: In factory system, the entities are customer order, parts and products.

## Attributes

- It denotes the property of an entity.
- Example: In factory system, attributes be quantity for each order, type of part, no. of machine in production department

## Activity

- Any process that causes changes in a system is called activity.
- Example: In factory system, the activity is manufacturing process of department.

## State of the System

- The State of the System can be defined as the collection of variables necessary to describe the system at any time, relative to the objective of study.
- In other words, the state of system means the collection of all entities, attributes and activities at one point in time is called the State of the system.

# Event

- It is defined as the instantaneous occurrence that may change the state of the system.

# Some other examples of systems are given below:-

| S.N. | System | Entity | Attributes | Activity | Event | State Variables |
|---|---|---|---|---|---|---|
| 1 | Supermarket | Customer | Shopping List | Checking Out | Arrival Departure | No. of shoppers in line |
| 2 | Communication | Sender Receiver Message | Message Length Priority | Transmitting | Arrival at Destination | No. of waiting to be transmitted |
| 3 | Production System | Machines | Speed Capacity | Welding Sampling | Breakdown | Status of Machine(busy, idle or down) |
| 4 | Bank | Banker Account Holder | Cash, Cheque | Transaction | Arrival, Departure | No. of busy tellers, No. of customers waiting |

## Task 1:

Taking reference of given four system, identify the entities, attributes, activity, event and state variables .

- Telephone System
- Traffic System
- Transportation operation System
- Hospital Facilities System

# System Environment

- Sometime a system is affected by change occurring outside the system.
- Such changes occurring outside the system are said to occur in system environment.
- So it is very important to study the boundary between the system and its environment while modeling a system.
- Eg: In case of factory system, factors controlling the arrival of orders may be considered to be influence of  the factory system(i.e. part of the environment).

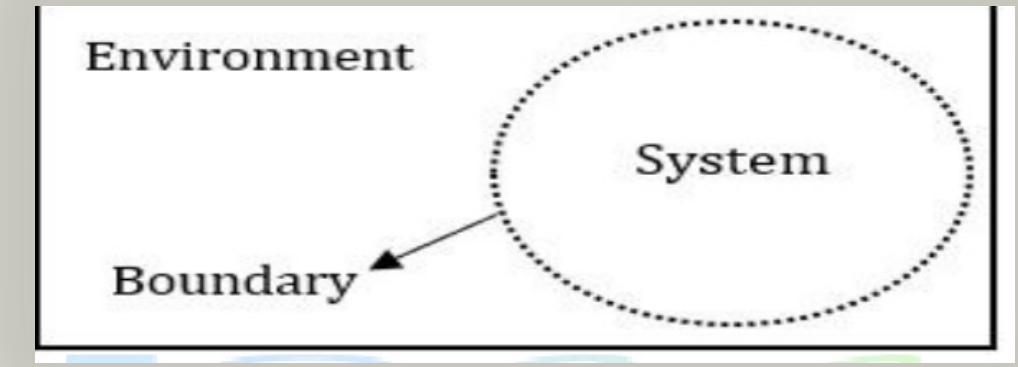



**Fig:** System Environment

# Types of Activities

- Endogenous Activity
- Exogeneous Activity
- Deterministic Activity
- Stochastic Activity

# Endogeneous Activity

- It is the activity occurring within the system.
- Example: manufacturing activity in factory system..

## Exogeneous Activity

- Activity occurring outside the system i.e. in environment.
- Example: Arrival of orders

# Deterministic Activity

- It is the activities whose outcome can be described completely in terms of its Input.

## Stochastic Activity

- If output of an activity cannot be completely described in terms of its input or it vary randomly over various possible outcome, those activity are said to be stochastic.
- Eg: The randomness of stochastic is the part of the system because the exact at any time is unknown.
- However the random output can be measured and described in a probability distribution.

# Types of System

- Continuous and Discrete System
- Static and  Dynamic System
- Stochastic and Deterministic System
- Open and Close System

# Continuous System

- Those system whose state variable changes continuously with time.
- Eg: Aeroplane moving in air (Aircraft System)
- State variable: Position and velocity

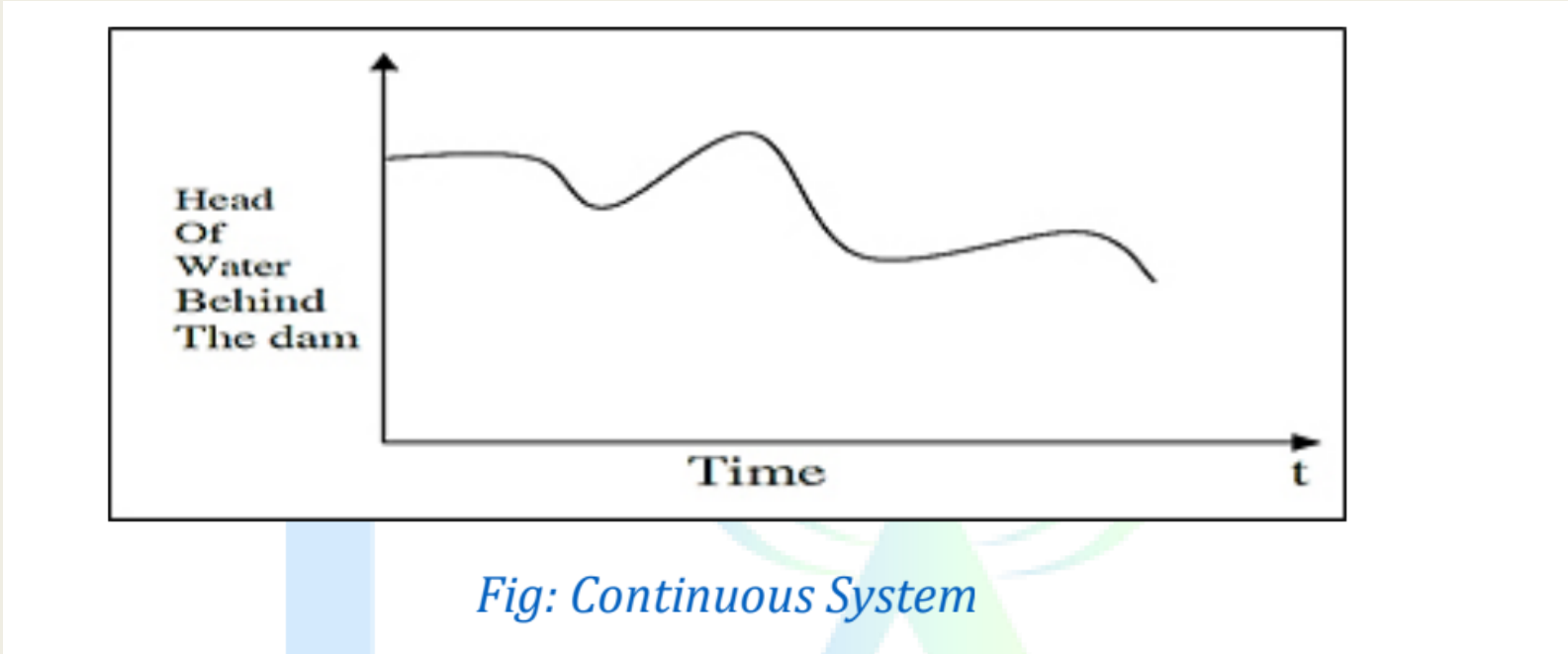



*Fig: Continuous System*

# Discrete System

- Those system whose state variable changes instantly at separate points in time..
- Eg: Bank System, because the number of customers ma arrive only when a new customer enters or leaves bank.

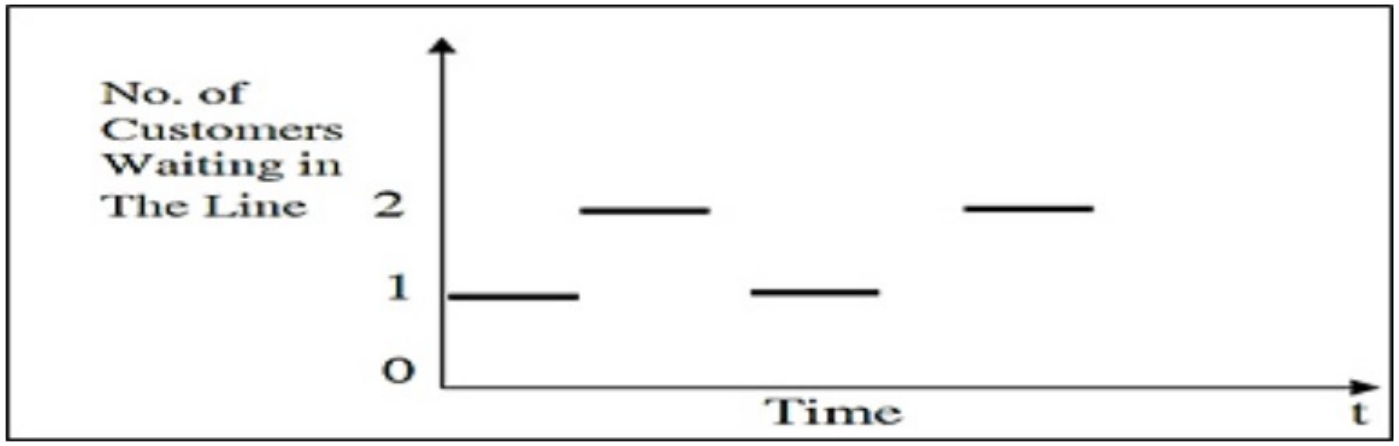



*Fig: Discrete System*

# Static and Dynamic System

- Static System shows the value of system attributes when the system is in equilibrium or balanced.
- Dynamic system follows the changes over time that results from system activities.

# Stochastic and Deterministic System

- The system in which the outcome of an activity can be completely described in terms of its input are deterministic system.
- The system in which the outcome of an activity cannot be completely described in terms of its input or vary over various possible outcome is called stochastic system.

# Open and Close System

- A system for which there is no exogeneous activity is said to be open system otherwise it is called closed system.
- A close system is one when there is no interaction between the environment and the system components.

# System Modeling

- To study a system, sometimes it is possible to experiment with the system itself.
- But sometime it is not possible to experiment with the system while it is in hypothetical system.
- So model is the substitute for the system and is also the simplification of the system.
- The relevant and necessary information gathered about the system for study purpose is called system model.
- Studying of model instead of real system is much easier, faster, cheaper and safe.

# Deriving a Model

- The tasks of deriving a model of a system may be divided into following two subtasks:

  i. **Establishing a model structure**:

     In this phase, It determines the system boundary and identifies the entities, attributes and activities.

  i. **Supplying the data**:
     In this phase, it provides the value of attributes and defines the relationship between the activities involved.

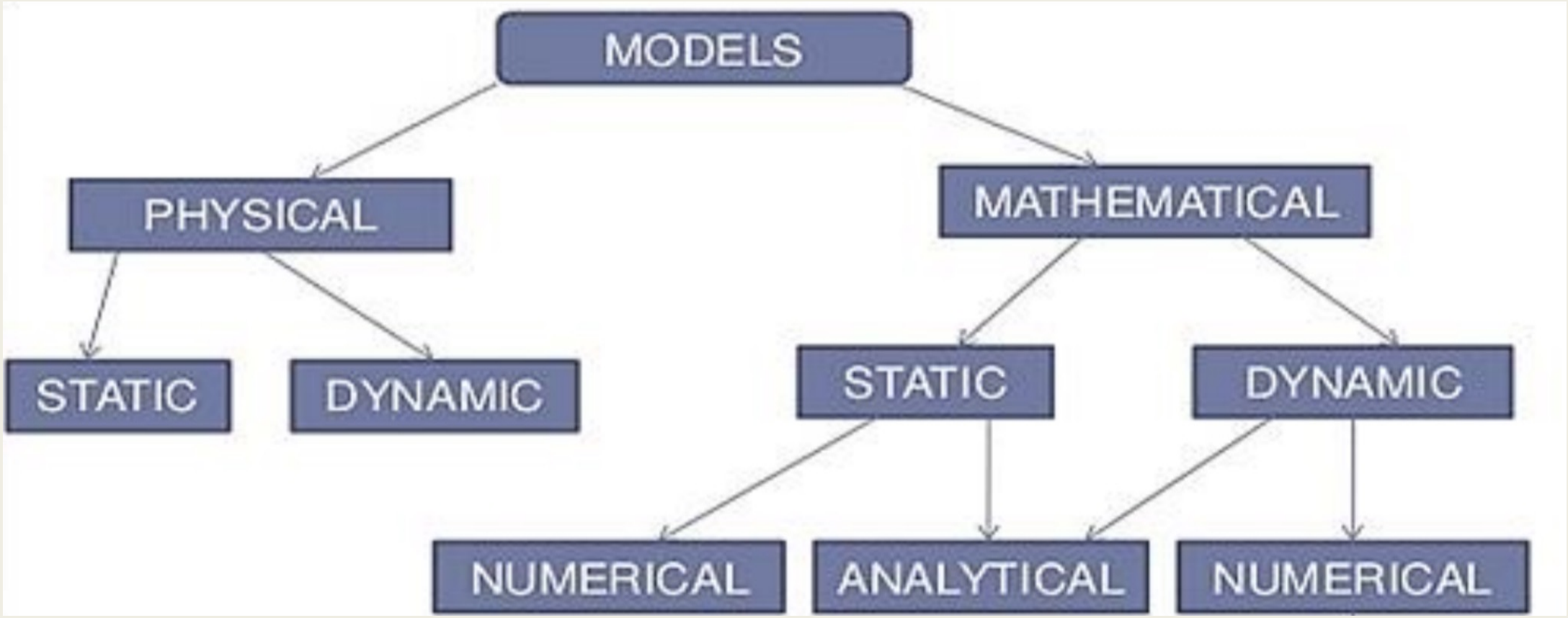
# Process Illustration of System Model

- Let’s take an Case Study of Supermarket:

  Shoppers needing several items of shopping arrive at super market. The get a basket of one available, carry out their shopping and then queue to checkout at one of the several counter. After checking out, they return the basket and leave.

  Here, in the assumption of the supermarket system. The entities are shoppers, basket, item and counter. The attributes are number of items, availability of basket and no. of occupancy. The activities are arrival of customer, getting a basket, payment, returning a basket and leave the supermarket.

# Types of Model

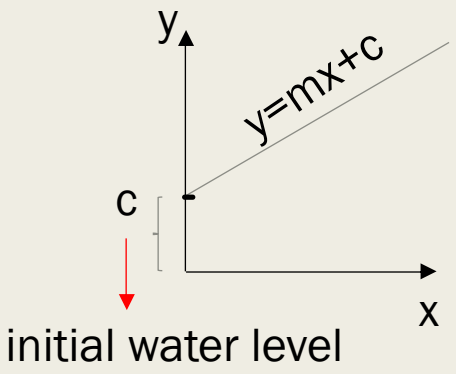


# Physical Model

- In physical model of a system, the system attributes are represented by measurement such as voltage or position of shaft.
- Hence the system activities are deflected in physical  logic that derived a model.
- Ex: The rate at which the shaft of DC motor rotates depends on the voltage applied to the motor. If the applied voltage is used to represent the velocity of vehicle, then the no. of revolution of shaft is measure of the distance the vehicle has travelled

# Mathematical Model

- Under mathematical model, this model uses symbolic notations and mathematical equations to represent a system.
- In this model, attributes are represented by variable and activities are represented by mathematical function that interrelates variable.
- E.g.



- Suppose we wish to construct a model to show how water level changes with time so as to predict how long it will take to fill the whole water tank.
- We can model this system by using simple linear functions as below,

$$y = mx + c$$

where, c is the initial water level,

x is the time

m is the slope that determines the rate of flowing of water and

y is the water level at any time x.

# Static Physical Model

- A model that can only show the value that system attributes can take when the system is in balance is called static model.
- These model looks like a real system which are to be modeled.
- The best example of static physical model is ‘scale model’.

  A ‘**Scale models**’ are the representation or copy of the objects that is larger or smaller than the actual size of the object.
- In Construction of college building, we use scale model for determining the exact model of classroom, library, ground etc.
- Another example of static physical model is the model in which scientist used in which sphere represents atoms and rods represents bonds.

# Dynamic Physical Model

- A model that can show the value of system attributes that changes over time as a result of system activities is called **dynamic model**.
- It is the physical model that represents the behavior of the system when it is not in equilibrium.

# Static Mathematical Model

- This model gives the relationship between system attributes when system is in equilibrium

# Numeric Method/ Simulation Method

- If an analytical solution to mathematical model is available and computationaly efficient, it is usually desirable to study the model using analytical method.
- However, many systems are highly complex so valid mathematical model of them are also complex.
- In such case, the model must be studied by means of simulation i.e. numerically exercising the model for inputs in questions to see how the affect the output measure of performance.
- It produces  solution in each step, each  step gives solution for once, at a condition and calculation is repeated until a final solution is obtained.

# Principle Used in Modeling

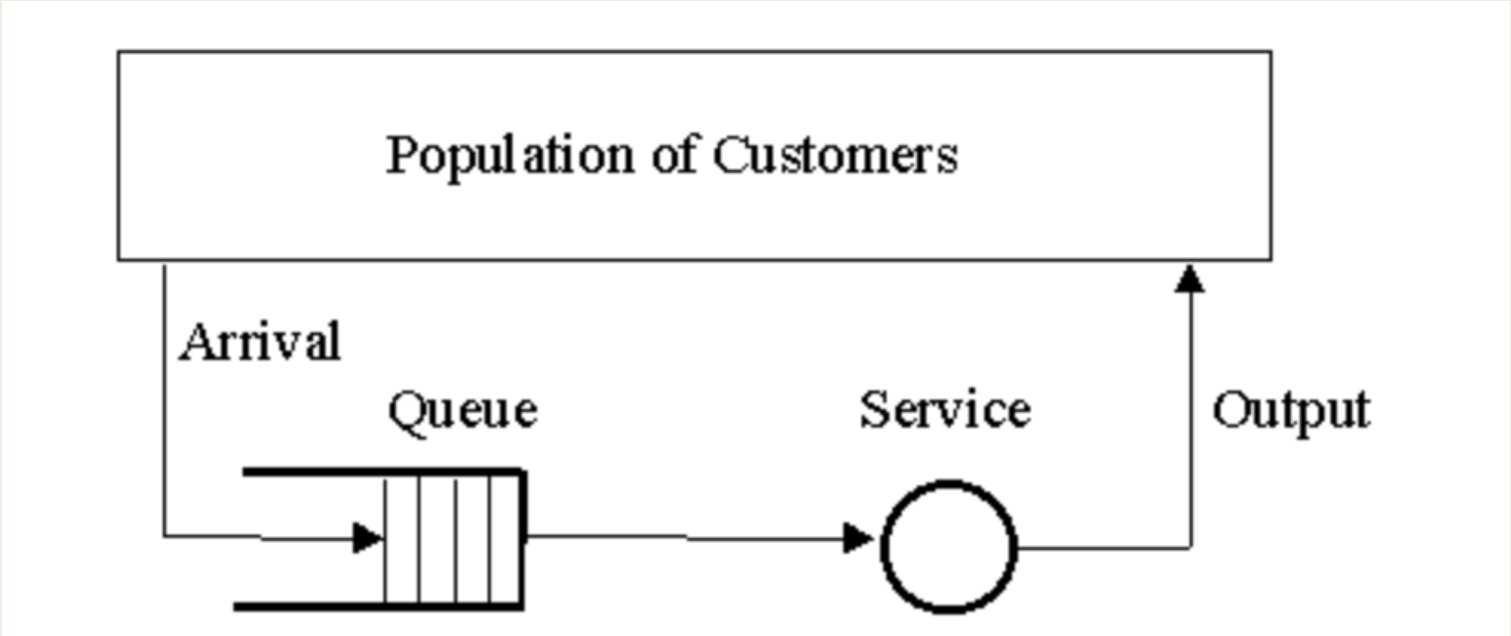



Fig 1: Queuing Model

- This provides the guidelines that provide different viewpoints to be judged while defining a model.

## a. Building Block

- Description of system should be organized in series of block.
- Each block describes part of a system.
- Each block results in few input parameters and result is few output parameters.
- System is described as interconnection of these blocks.
- The system can be represented graphically as a simple block diagram. Eg: Fig1: Queuing Model

# b. Relevance

- ✓ Models should include relevant aspect of system.
- ✓ If irrelevant information are considered in our models then it ma harm our model but the complexity of the model increases.
- ✓ Eg: In a factory system, if the system aim is to compare the effect of different operating rules on efficiency , it is not relevant to consider the hiring of employee as an activity.

# c. Accuracy

- Whatever the information is gathered for model, it must be correct and accurate.

# d. Aggregation

- It is the extend to which the number of individual entities can be grouped together into larger entities.
- **Example:** In case of factory system, the general manager of the factor may be satisfied with the description that can be given. However, the production control manages, may want to consider the shops of the department as an individual entity.

# Introduction to Simulation

- It is one of the most powerful tool available to decision maker responsible for the design and operation of complex process and system.
- It makes possible to study analysis and evaluation of situation that wouldn’t be otherwise possible.
- Simulation can be defined as process of designing a model of real system and conducting experiments with these models and evaluating various strategies for the operation of the system.

# Advantages of Simulation

- We can test new design without assigning resources to their implementation.
- It can be used to explore new staffing policy, operating procedures, design rules, organizational structure etc. without disturbing an ongoing operations.
- Time can be compressed or expanded according to need under investigation.

# Contd…

- It’s great strength is its ability to let us experiment with new unfamiliar situations
- It allows us to gain the idea about how a system actually works and provides understanding of which parameters are important up to performance.

# 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 consuming and expensive.
- Simulations are used in cases when analytical solutions are possible.
- Lack of knowledge about simulation method in people.
- Writing Computer Program to define and execute a model is time consuming task.

# Verification and Validation

- A model is the substitute for the system to be studied and also is the simplification of system.
- The relevant and necessary information gathered about the system for study purpose is called **model**.
- One of the most important and difficult task for a model developer is verification and validation of simulation on model.
- **Verification** deals with building model right and **Validation** deals with building right model.

# Verification

- It is concerned with building model right.
- It is utilized in the comparison of the conceptual model to the computer representation that implements the conception.
- The main purpose of model verification is to assure that the conceptual model is reflected accurately in computerized representation.
- It asks the following questions:
  - Is the model  implemented correctly in the computer ?
  - Are the input parameters and structure of the model correctly represented?

# Validation

- It deals with building right model.
- It is utilized to determine that a model is an accurate representation of a real system.
- Validation is usually achieved through the calibration of the model, which is an iterative process of comparing the model to the actual system behavior and using the difference two to improve the model..
- This process is repeated until the model accuracy is judged to be acceptable.