→ The output must supervised by system expert.

Step 2:

This can be achieved by applying the assumption data into the model and testing. It quantitatively sensitive analytical and can also be performed to observed the effect of change in the result when significant change are made in input data.

Step 3:

This can be achieved by using following steps:-

→ Determine the simulation output with the real system output.

→ Comparison can be performed using the turning test. It represents the data in system board format wh can be explained by experts only.

→ Statistical method can be used for compare the model output with the real system output.

reviews to objective statistical tests. One approach that is commonly used is to have the model builders determine validity of the model through a series of tests. So, verification and validation is required in simulation.

11. What are the steps of validation? Explain.

→ The steps of validation are :-

Step 1: Build a model that has high face validity.

Step 2: Validate model assumptions.

Step 3: compare the model input-output transformations to corresponding input-output transformations for the real system.

→ It's explanation are:-

Step 1:
This can be achieved using following steps:-

→ The model must be discussed with the system experts while designing.

→ The model must interact with the client throughout the process.

10. Why is verification and validation required in simulation? Explain with suitable example.

→ Verification and validation of computer simulation models is conducted during the development of a simulation model with the ultimate goal of producing an accurate and credible model. Simulation models are approximate imitations of real-world systems and they never exactly imitate the real-world system. Due to that, a model should be verified and validated to the degree needed for the models intended purpose or application.

There are many techniques that can be utilized to verify a model. Including but not limited to have the model checked by an expert, making logic flow diagrams that include each logically possible action examining the model output for reasonableness under a variety of settings of the input parameters, & using an interactive debugger.

Validation checks the accuracy of the models representation of the real system. Model validation is defined to mean substantiation that a computerized model within its domain of applicability possesses a satisfactory range of accuracy consistent with the intended application of the model. There are many approaches that can be used to validate a computer model. The approaches range from subjecti

RLC circuit is represented as:-

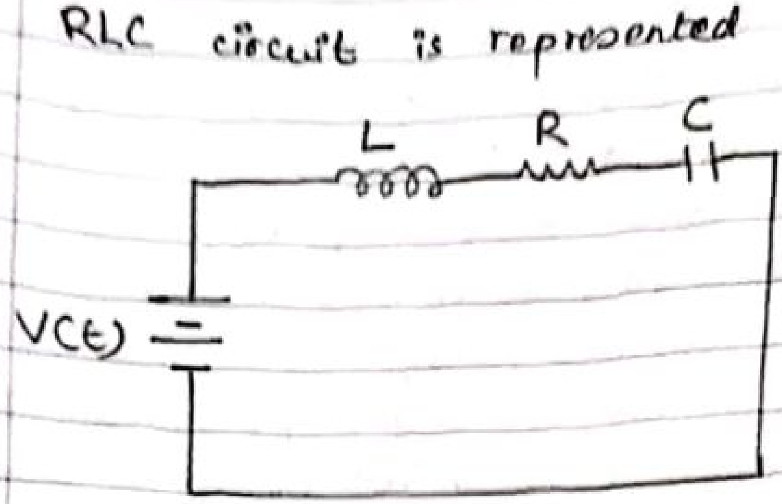


Fig: LRC circuit

from above circuit;

$$L\ddot{q} + R\dot{q} + \frac{q}{C} = \frac{V(t)}{C} \quad \cdots\cdots (3)$$

where, L = inductance

R = Resistance

C = capacitance

$V(t)$ = voltage dependent on time.

q = charge

$\dot{q} = \frac{dq}{dt}$ = current

$\ddot{q} = \frac{d^2q}{dt^2}$ = voltage

Comparing eq^{n} (2) & (3);

$$L = M + M_1$$

$$R = D$$

$$\frac{1}{C} = k$$

$$k = \frac{1}{C} \quad \text{or} \quad C = \frac{1}{k}$$

9. Suppose the automobile body in the suspension system example in not stationary. Consider the body to have a mass of M_1 and assume that its motion is determined by the force of gravity and the reaction with the suspension system. Construct a model for the motions of the wheel and body.

→ According to the question, a model for the motions of the wheel and body can be constructed as;

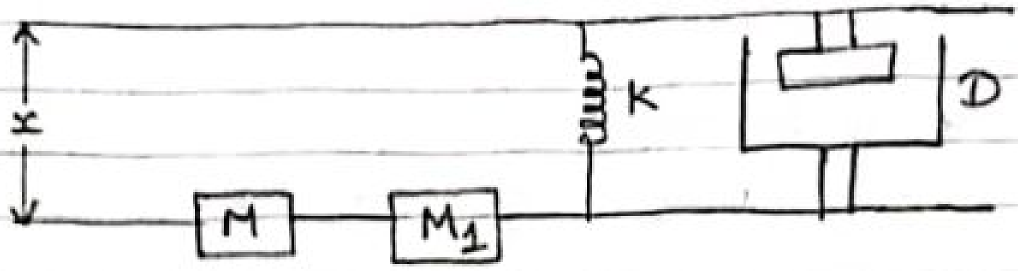


Fig: suspended weight attached with spring and piston me

From fig, the eq^n of motion i.e,

$$M\ddot{x} + M_1\ddot{x} + D\dot{x} + kx = F(t) \quad \dots (1)$$

where,

k = spring constant
M = mass of wheel
M_1 = mass of body
x = Displacement
D = Damping factor
$\ddot{x}$ = acceleration
$\dot{x}$ = velocity.

Then eq^n (1) becomes;

$$(M + M_1)\ddot{x} + D\dot{x} + kx = F(t) \quad \dots (2)$$

Also, the motion of the aircraft can also be measured by instrument electrical signal that can be added to the o/p of output. The modification affect the aircraft response by changing applied time.

i.e. $F(t) = k\varepsilon + k\int \varepsilon \, dt$

with this modification control theory show that for the system to remain stable, we must have

$$\boxed{k < \frac{kD}{I}}$$

If we divide both side by I, and move the following substitution;

$$2\xi_p \omega = \frac{D}{I}, \quad \omega^2 = \frac{k}{I}$$

The eqn of motion releasing o/p to input then takes the following form:

$$\ddot{y}_0 + 2\xi_p \omega \dot{y}_0 + \omega^2 y_0 = \omega^2 y_1 \quad \ldots (6)$$

From eqn (5) & (6);

$$\frac{D}{I} = 2\xi_p \omega \quad \& \quad \omega^2 = \frac{k}{I}.$$

$$\therefore \omega = \sqrt{\frac{K}{I}}$$

$$\xi_p = \frac{D}{2I\omega}$$

$$\xi_p = \frac{D}{2I\sqrt{\frac{K}{I}}}$$

$$\therefore \xi_p = \frac{D}{2\sqrt{KI}}$$

For oscillation, we know $\xi_p < 1$.

$$\frac{D}{2\sqrt{KI}} < 1$$

$$D < 2\sqrt{KI}$$

$$D^2 < 4KI$$

which is required condition.

8. In the aircraft system, suppose the control surface angle Y is made to be A times the error signal. The response of the aircraft to the control surface is found to be I. Find the necessary conditions under which the aircraft motion is oscillatory.

→ According to the question;

$$Y = A\varepsilon \quad \cdots (1)$$

where;

Y = control surface angle

ε = error signal

& $\varepsilon = y_1 - y_0 \quad \cdots (2)$

The torque existing on the aircraft can be represente as;

$$\text{Torque} = K\varepsilon - Dy_0 \quad \cdots (3)$$

Since the angular acceleration of the aircraft is the derivation of its heading the motion is;

$$I\dot{Q}S = \text{torque} \quad \cdots (4)$$

from eq^n (3) & (4);

$$I\ddot{y}_0 + D\dot{y}_0 + ky_0 = ky_1 \quad \cdots (5)$$

Eq^n of damping motion is given by;

$$\ddot{x} + 2\xi_f \omega \dot{x} + \omega^2 x = \omega^2 F(t) \quad \cdots (3)$$

Comparing (2) & (3);

$$2\xi_f \omega = \frac{D}{M} \quad \text{and} \quad \omega^2 = \frac{K}{M}.$$

$$\text{or, } \omega = \sqrt{\frac{K}{M}}.$$

$$\xi_f = \frac{D}{2M\omega}$$

$$= \frac{D}{2M\sqrt{\frac{K}{M}}}$$

$$= \frac{D}{2\sqrt{KM}}$$

For no oscillation;

$$\xi_f \geq 1$$

$$\frac{D}{2\sqrt{KM}} \geq 1$$

$$D \geq 2\sqrt{KM}$$

$$D^2 \geq 4KM$$

$$\therefore \boxed{D^2 \geq 4KM}$$

which is required condition.

7. Derive the conditions for non oscillatory condition of automobile wheel. Assume necessary variables and condition as required.

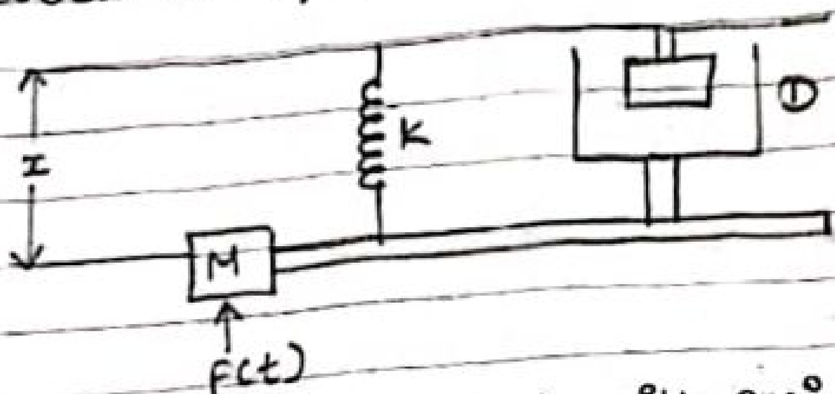


Fig: Suspended weight attached with spring and piston.

From the above figure, the proportion of the system can be represented as:

$$M\ddot{x} + D\dot{x} + Kx = F(t) \quad \cdots (1)$$

where,

M = Mass of wheel.

D = Damping factor

K = Spring constant

x = Displacement

$\dot{x} = \frac{dx}{dt}$ = velocity

$\ddot{x} = \frac{d^2x}{dt^2}$ = acceleration.

from eq^n (1);

$$\ddot{x} + \frac{D}{M}\dot{x} + \frac{k}{M}x = \frac{F(t)}{M} \quad \cdots (2)$$

Also, for no oscillation,

$$\xi \geq 1$$

$$\frac{D}{2\sqrt{K(D_2+M)}} \geq 1$$

$$\Rightarrow D \geq 2\sqrt{K(D_2+M)}$$

$$\Rightarrow D^2 \geq 4K(D_2+M)$$

$$\therefore \boxed{K = \frac{D^2}{4(D_2+M)}}$$

which is required expression for ensuring the wheel tha does not oscillate.

$\because D = R$

$\therefore k = \frac{1}{C}$

$\therefore F(t) = E(t)$

For oscillation;

$$\ddot{x} + 2\xi_e \omega \dot{x} + \omega^2 x = \omega^2 F(t) \cdots (5)$$

From (3) & (5);

$$2\xi_e \omega = \frac{D}{D_2+M}$$

$$\omega^2 = \frac{k}{D_2+M}$$

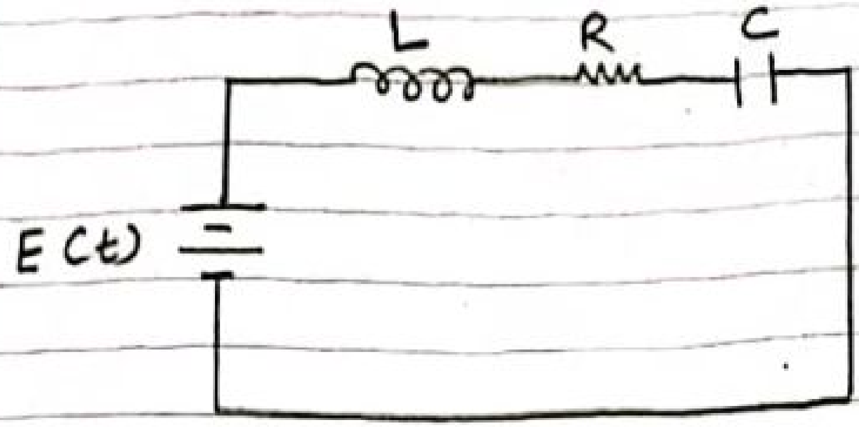
$$\therefore \omega = \sqrt{\frac{k}{D_2+M}}$$

$$\xi_e = \frac{1}{2}\sqrt{\frac{D_2+M}{k}} \times \frac{D}{D_2+M}$$

$$\xi_e = \frac{D}{2\sqrt{k(D_2+M)}}$$

which is required condition when $D = 2$ & $k \cdot (D_2+M) = 1$ then above relation shows that $\xi_e = 1$ which means system motion is not in oscillation.

Then, the LRC circuit is represented as:



From above fig;

$$L\ddot{q} + R\dot{q} + \frac{q}{C} = \frac{E(t)}{C} \quad \dots (4)$$

$\dot{q} = \frac{d\dot{q}}{dt}$ = current (rate of change of charge)

$\ddot{q} = \frac{d\ddot{q}}{dt^2}$ = voltage (rate of change of current)

where L = inductance
R = Resistance
C = Capacitance
q = change of capacitance
$E(t)$ = Voltage source varies with time.

Comparing eq^n (3) & (4);

$$M + D_2 = L$$
$$M = L - D_2$$

$F(t)$ = Applied force.

Also,

$$\dot{x} = \frac{dx}{dt} = \text{velocity} = \frac{\text{displacement}}{\text{time}}$$

$$\ddot{x} = \frac{d^2x}{dt^2} = \text{acceleration} = \text{Rate of change of velocity.}$$

According to the question, the shock absorber damping force is not strictly proportional to the velocity of the wheel.

i.e. D is not strictly proportional to $\dot{x}$.

Again, M is an additional force components equ to D_2 times the acceleration of the wheel.

i.e.

$$F_2(t) = D_2\ \ddot{x}$$

Then above eqn (1) becomes;

$$M\ddot{x} + D\dot{x} + D_2\ \ddot{x} + kx = kF(t) \cdots (2)$$

$$M\frac{dx^2}{dt^2} + D\frac{dx}{dt} + D_2\frac{dx^2}{dt^2} + kx = kF(t)$$

$$\frac{dx^2}{dt^2}(M + D_2) + D\frac{dx}{dt} + kx = kF(t) \cdots$$

6. In an automobile wheel suspension system, it is found that the shock absorber damping force is not strictly proportional to the velocity of the wheel. There is an additional force component equal to D2 times the acceleration of the wheel. Find the new condition for ensuring the wheel does not oscillate.

→

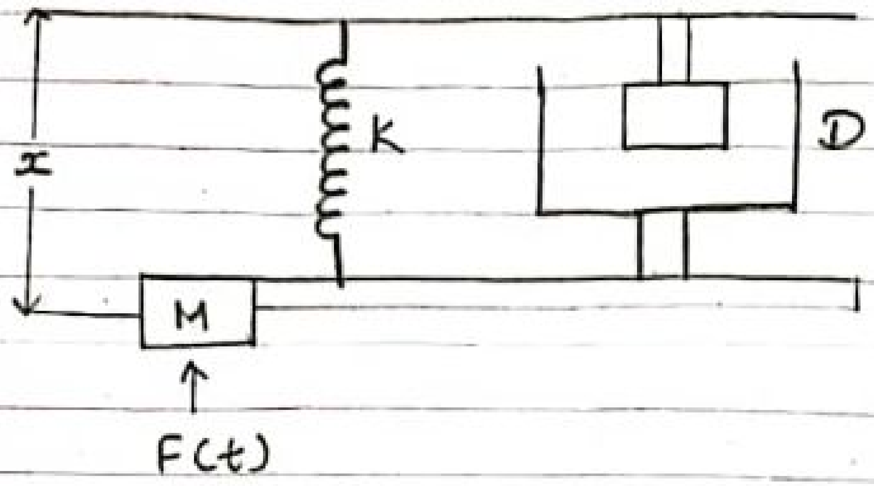


fig: Suspended weight attached with spring and piston.

From the above figure,

The motion of the system can be represented by the following differential equation;

$$M\ddot{x} + D\dot{x} + kx = k\,F(t) \quad \cdots (i)$$

where;

M = mass

D = Damping factor of shock absorber

k = stifness constant of spring

x = displacement of mass.

System Name	Entities	Attributes	Activities
Barber shop	→ Staff → services → Appointment → Feedback	→ Name → Address → Shop no.	→ cutting hair → service customer
College	→ Student → Lecture → Subjects → Admission	→ Firstname → Address → Birth date → Department name	→ study → class section → fee deposit

Example: An economic or social studies usually treats a population as a number of social classes and conduct the study as each social class as a distinct entity.

Name three or four on the principal entities, attribute and activities to be considered if you were to simulate the operation of:
A gasoline filling.
Cafeteria
Barber shop
College.

Any three on the principal entities, attribute & activities to be considered if I was to simulate the operation of these system are:-

System Name	Entities	Attributes	Activities
A gasoline filling	→ Road → Streams → gasoline filling station	→ Road-type → stream-type → Area	→ Service station → sell fue
Cafeteria	→ Customer → Cashier → Waiter → cook	→ Hungry → food type → Entree preference → Size of appetite	→ selecting food → paying for food

2. Relevance:-

The model should only include those aspects of the system that are relevant to the study of the objective. A relevant information should be excluded because it increases the complexity of the model and causes more work in solving the model.

3. Accuracy:-

The accuracy of the information gathered for the model should be considered. for example, In the aircraft system, the accuracy with which the movement of the aircraft is described depends upon the representation of the airframe. It may sufficient to regard the airframe as a rigid body and derive a very simple relationship between control surface movement and aircraft heading, it may be necessary to recognize the flexibility of the airframe and make allowance for vibrations in the structure.

4. Aggregation:-

It is the extent to which the number of individual entities can be grouped together into larger entities. In some studies it may be necessary to construct artificial entities through the process of aggregation.

numerical methods. Numerical methods involve applying computational procedures to solve equations.

System simulation is considered to be a numerical computation technique used in conjunction with dynamic mathematical models.

What are the principales used in modeling? Explain.

The principles used in modeling are:-

Block Building:-

The description of the system should be organized in a series of blocks. The aim in constructing the blocks is to simplify the specification of the interactions within the system. Each block describes a part of the system that depends upon a few, input variables and results in few output variables. The system as a whole can be described in terms of the interconnection between the blocks. Correspondingly, the system can be represented graphically as a simple block diagram.

Example: The description of a factory is an example of a block diagram where each department has been treated as a separate block where the inputs and outputs being the work passed from department to department.

are represented by such measurements as a voltage or the position of a shaft. The system activities are reflected in the physical laws that drive the model.

Mathematical models:-

The mathematical model use symbolic notations and mathematical equations to represent a system.

The system attributes are represented by variables and the activities that represented by mathematical functions that interrelate the variables.

A second distinction is between static models and dynamic models.

Static models can only show the values that system attributes take where the system is in balanced whereas Dynamic models follow the changes over time that result from system activities.

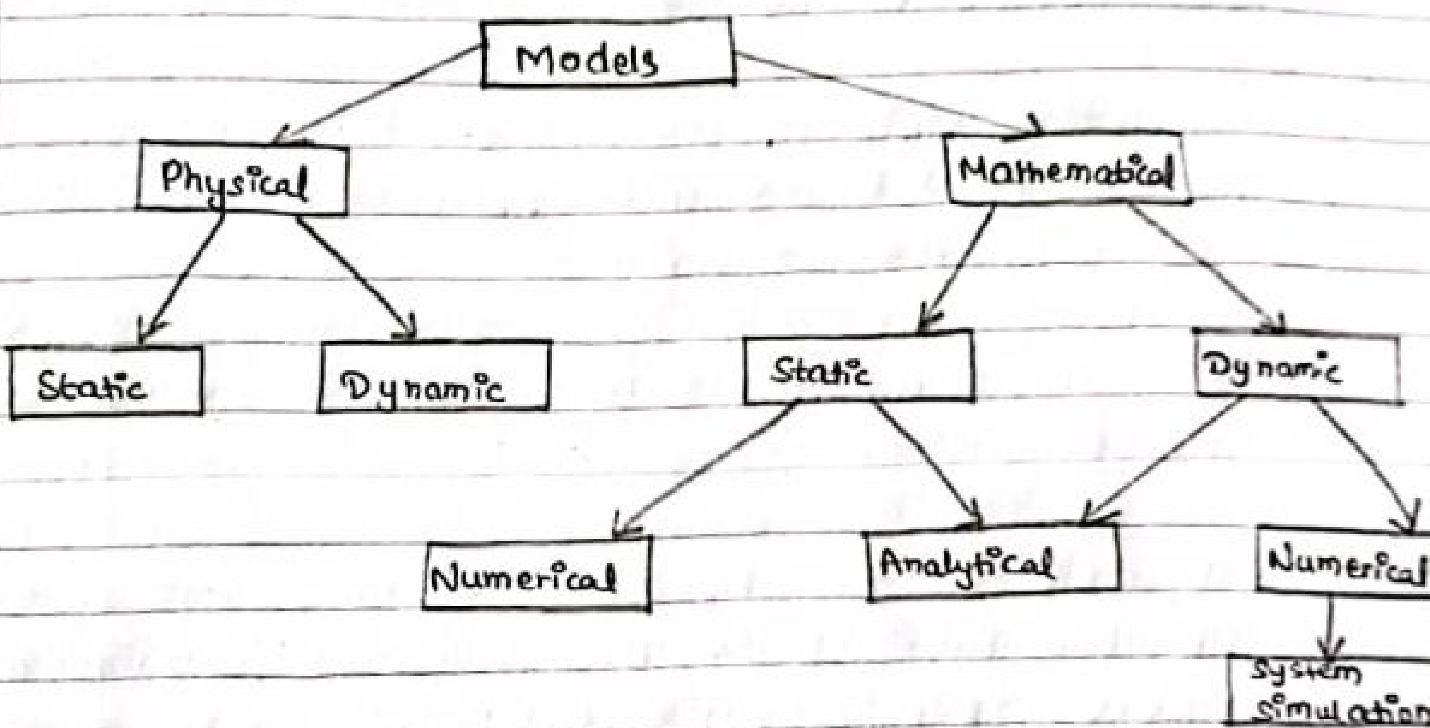
In case of mathematical model the third distinction is a technique by which the model is solved that is actual values are assigned to system attributes.

A distinction is made between analytical and numerical method. ~~Static~~ Applying analytical technique means using the deductive reasoning of mathematical theory to solve a model. Any assignment of numerical values that uses mathematical tables involves

3. What is Model? What are the types of model? Explain.

→ The model is defined as the body of Information about a system gathered for the purpose of studying the system.

Types of Model are:-



→ Models are broadly classified into:
1. Physical models
2. Mathematical models.

Physical models:-

Physical models are based on some analogy between such systems as mechanical and electrical or hydraulic and electrical.

In a physical model of a system, the system attributes of item to be purchased. In the second case, where allowance for congestion must be made, two approaches could be taken. It may be necessary to introduce new entities representing the various sections of the supermarket and establish as attributes the number of customers they can serve simultaneously. Alternatively, the activity of shopping could be represented by a function in which shopping time depends upon the number of shoppers in the supermarket.

2. What is System Modeling ? Explain with reference of supermarket model.

→ System Modeling is the process of creating abstract representations of complex systems to understand their behavior, predict outcomes and design improvements.

Consider the description of a supermarket model

Entity	Attribute	Activity
Shopper	No of items	Arrive, get
Basket	Availability	Shop Queue Check-out
counter	Number occupancy	Return Leave

Fig: Elements of a supermarket model.

In Fig, its identify the entities, attributes and activities. It illustrates the process involved in forming a model. It defines the system boundary and distinguishes between the system and its environment.

In supermarket model, the first case where type of item is to be distinguished, it is necessary to define several attributes for each customer, one for each type each order, type of part, or number of machines in a department.

The activities are the manufacturing processes of the departments.

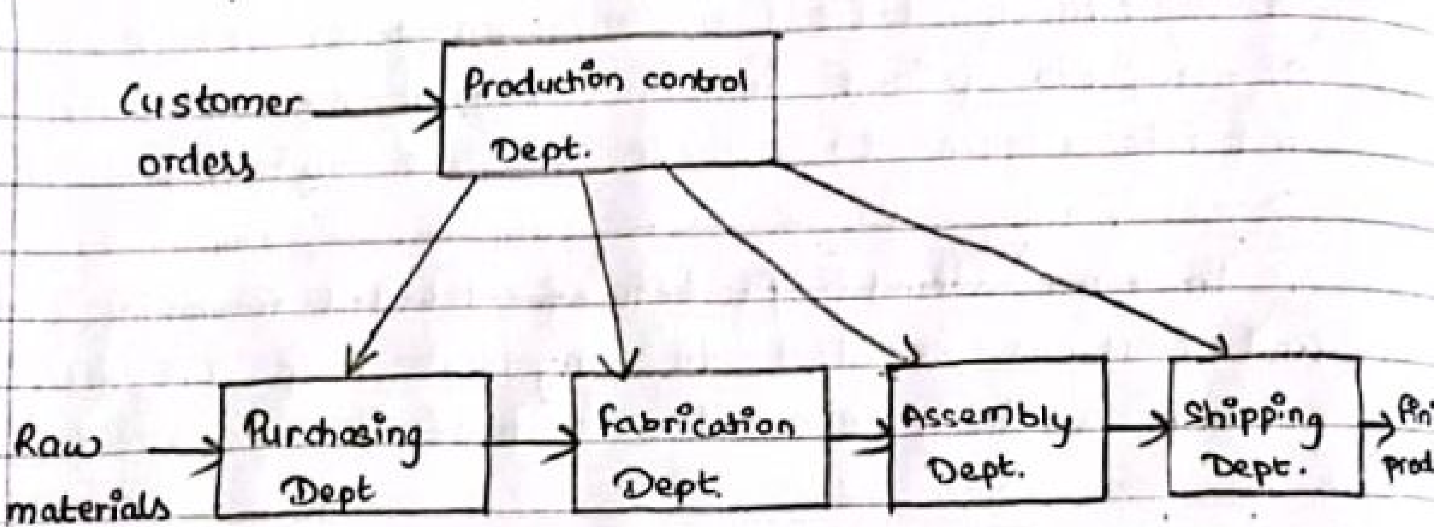


Figure: A factory system.

Assignment 1

1. What is System? What are the basic components of system? Explain with suitable example.

→ A system is defined as an aggregation or assemblage of objects joined in some regular interaction or interdependence to achieve system's objectives.

In other words, A set of detailed methods, procedure and routines created to carry out a specific activity, perform a duty or solve a problem is called a system

The basic components of system are:-

① Entity :- It is used to denote an object of interest in a system.

② Attribute :- It denotes a property of an entity.

③ Activity :- Any process that causes changes in the system is called as an activity.

Example of a factory system:-

In the factory system, the entities are the departments orders, parts and products.

Attributes are such factors as the quantities for