Defination of a control system:-

A system that manages, commands, directs or regulates the behaviour of other devices or systems.

- ఇది ఒక system, మనం చెప్పినట్టు వేరే machines or devices ని control చేస్తుంది.

Control systems are 2 types → open-loop ⇒ NO-feedback
→ closed-loop ⇒ uses feedback to adjust output

1. Advantages of closed-loop systems :- : Accuracy
• Error correction
• Disturbance rejection.

* But more complex and costlier than open-loop systems.

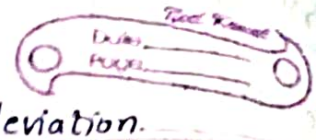
Basic Elements of a control system:-

⇒ 1. Input
2. controller
3. Actuator
4. process/plant
5. output
6. Feedback sensor.

Examples of control system

⇒ Cruise control
⇒ fan speed regulator
⇒ air conditioner
⇒ autopilot systems.

purpose of feedback



Feedback helps maintain the desired output by comparing actual output with desired Input and correcting any deviation.

⇒ 1. Mathematical modelling :- Systems are modeled using differential equations or transfer functions for analysis.

⇒ Block Diagrams :-
Representation of a control system using blocks to show components and their connections.

⇒ control system objectives

- Stability
- Accuracy
- Speed of response
- Disturbance Rejection
- Robustness.

Course overview :- Designing controllers for dynamic systems.

Approach :- Visualizing systems in terms of inputs and outputs.

Example :- DC Motor
⇒ Input :- Voltage
Output :- Rotational speed (RPM)
Goal :- Find the input voltage that produces the desired output speed.

Dynamic-systems Representation

⇒ Emphasis on transfer function
⇒ also touches state-space.

controller design

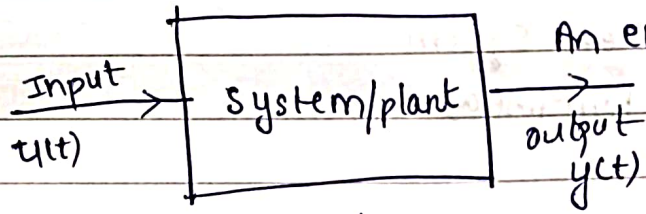
⇒ focused on PID controllers

P → proportional
I → Integral
D → derivative

** performance Quantification tools:-

→ Root locus
⇒ Bode plot
⇒ Nyquist plot
⇒ Routh's stability criterion.

System:-



An entity to which we give an input u(t) and get an output y(t)

Dynamic system

⇓

Inputs, outputs are functions of time.

⇒ Time is independent variable
⇒ All variables are functions of time
⇓
associated with system

System:- A collection of objects (a process) that is under study.

linear Time Invariant system

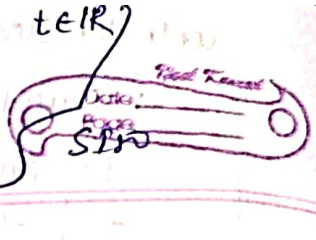
Mathematically, we can visualize a dynamic system as a mapping from u(t) to y(t). That is, $y(t) = S(u(t))$

classification of Dynamic systems:-

(1) SISO Vs MIMO

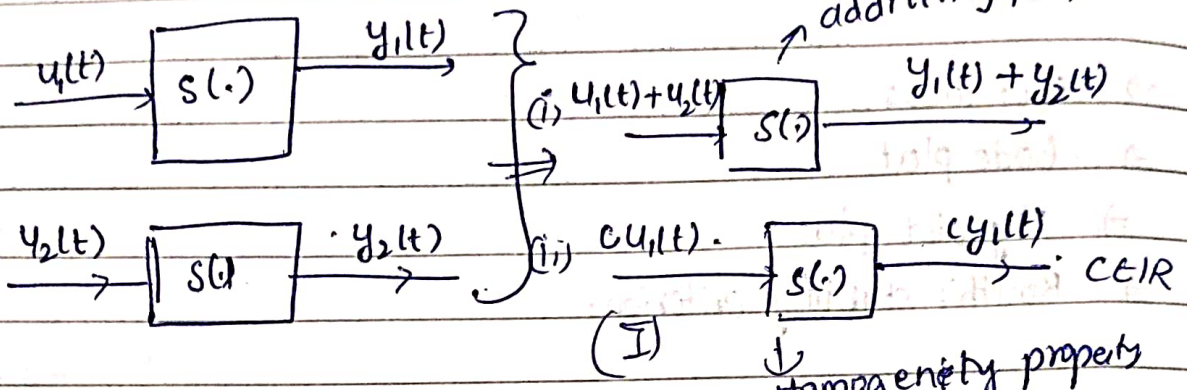
SISO:- Single Input single output system → $u(\cdot): \mathbb{R} \to \mathbb{R}$ $t \in \mathbb{R}$

MIMO:- Multiple Input Multiple output system → $y(\cdot): \mathbb{R} \to \mathbb{R}$

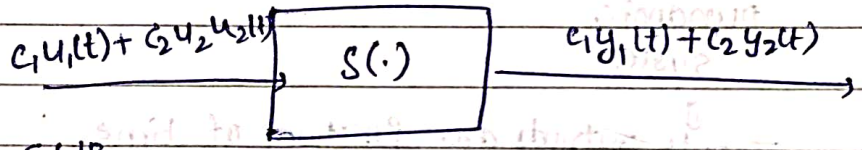


m inputs
p outputs
$m \geq 1$
$p \geq 1$
$u(\cdot): \mathbb{R} \to \mathbb{R}^m$
$y(\cdot): \mathbb{R} \to \mathbb{R}^p$

2) Linear vls Nonlinear:-



When (i) and (ii) are satisfied
then it is called linear system
otherwise Non-linear

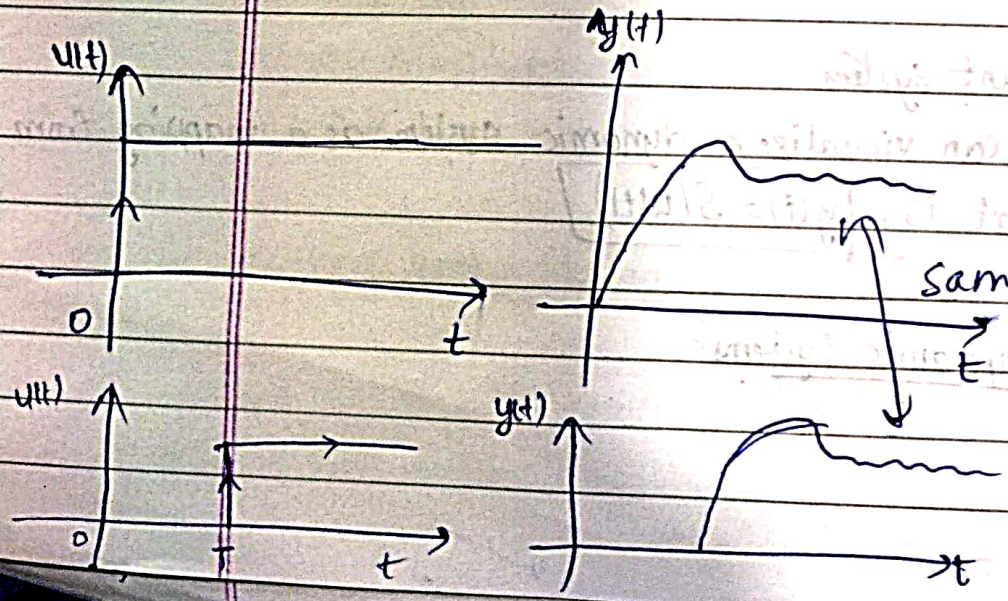


$c_1 \in \mathbb{R}$
$c_2 \in \mathbb{R}$

(II)

principle of superposition.

3) Time varying system or Time Invarying system



Same Then system is said to be Time invariant

A Time invariant system is one that provides the same output for the same input irrespective of when input is given

We work with Time Invariant system

mathematically $y(t) = s(u(t))$

then Time invariance implies $\Rightarrow$ $\boxed{y(t-\tau) = s(u(t-\tau))}$ $\forall\ \tau \in \mathbb{R}$

(4) Causal & Non-causal system :-

A causal system is one where the output at any instant of time depends only on past and current inputs

$\Rightarrow$ A causal system is NON-ANTICIPATIVE

Not depending on future inputs.

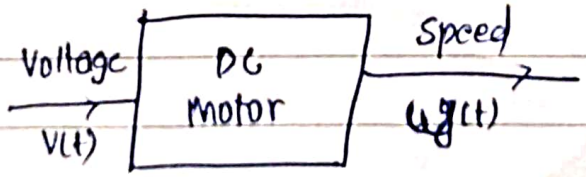
If $y(t) \Rightarrow$ depends on $x(t), x(t-1), x(t-2) \ldots \Rightarrow$ it's causal & non-anticipative

if $y(t) \rightarrow$ depends on $x(t+k)$ $k>0 \Rightarrow$ it's non-causal & anticipative.

class of systems $\Rightarrow$ we are going to focus :- SISO LINEAR TIME INVARIANT CAUSAL DYNAMIC SYSTEMS $\Rightarrow$ useful class

LTI

CONTROL :- Making a system behave as desired



Q : If we wish to achieve a ω_{des}, what is the input voltage that should be provided ?

Approach :- (1) develop a mathematical representation for S() $\rightarrow$ mathematical modelling

→ mathematical modelling of dynamic systems

2) Analyse the system response

3) Design the controllers

↓

1. physics based
2. Data Driven/ Empirical
3. Mixed approach