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Q (1)

A)

Control System:-

A Control system is a system of devices that manages, commands, directs or regulates the behavior of other devices to achieve a desired result

in another words "The definition of controll system can be simplified as a system which control other systems to achieve a desired state.

Why we use control System

* Modern control theory is based on time-domain analysis of differential equation system
* Modern control theory made design of control system simples because the theory is based on a model of an actual control System

* The system's stability is sensitive to the error between the actual system & its model

* when the designed controller based on a model is applied to the actual system, the system may not be stable. To avoid this saturation we design the control system by first setting up the range of possible errors & then designing the controller in such a way that, If the error of the system stay with in the assumed range, the designed control system will stay stable.

(3)

Q.1 (b)

Open loop

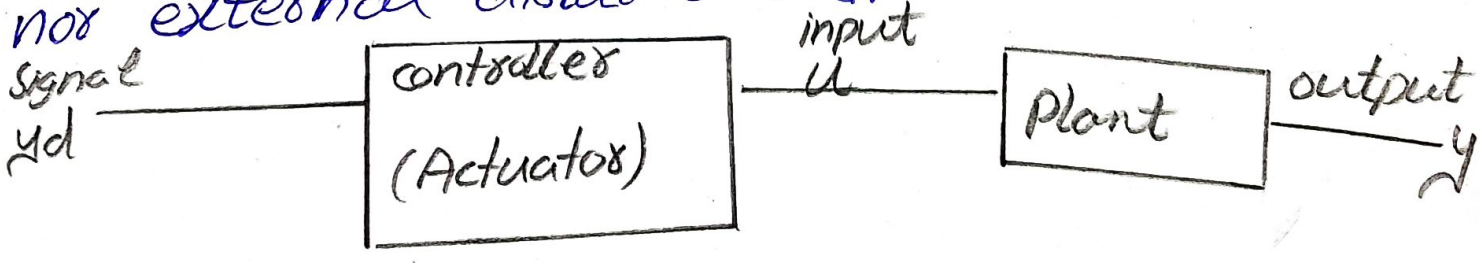
Those system in which the output has no effect on control action are called open-loop control system

In other words, In an open loop control system the output is neither measured nor fed back for comparison with the input.

Explaination:

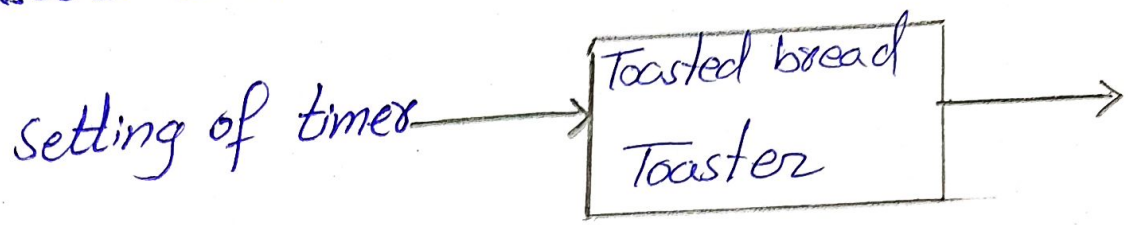
In any open-loop control system the output is not compared with the reference input. Thus, to each reference input there corresponds a fixed operating condition, In the presence of disturbences an open-loop control system will not perform the desired task.

open loop control can be used, in practice, only if the relationship between the input and output is known and if there are neither internal nor external disturbences.



Example

A toaster toasts bread, by setting timer



- objective:

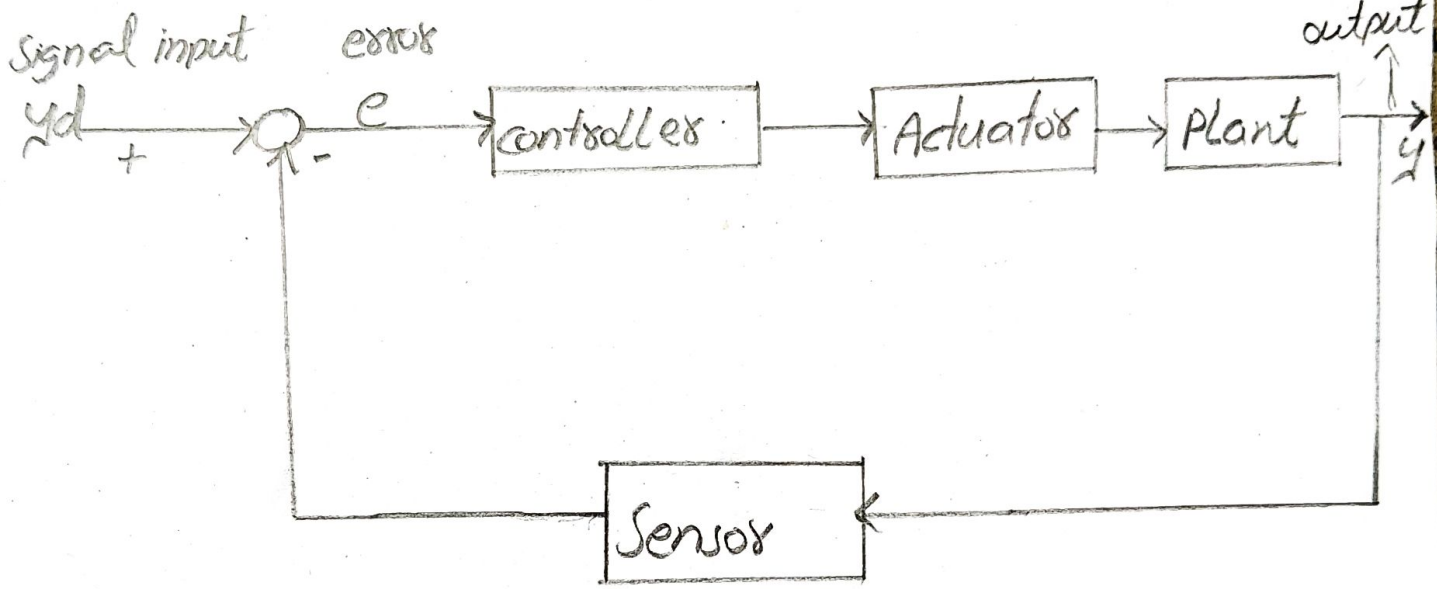
* Make bread golden browned & crisp
* A Toaster does not measure the color of bread during the toasting process.
* For a fixed setting, in winter, the toast can be white & in summer, the toast can be black
* A toaster would be more expensive with sensors to measure the color & actuator to adjust the timer based on measured color.

Close Loop

In a closed-loop control system the actuating error signal, which is the difference between the input signal & the feedback signal is fed to the controller, so as to reduce the error & bring the output of the system to desired value.

Compare Actual behavior with desired behavior

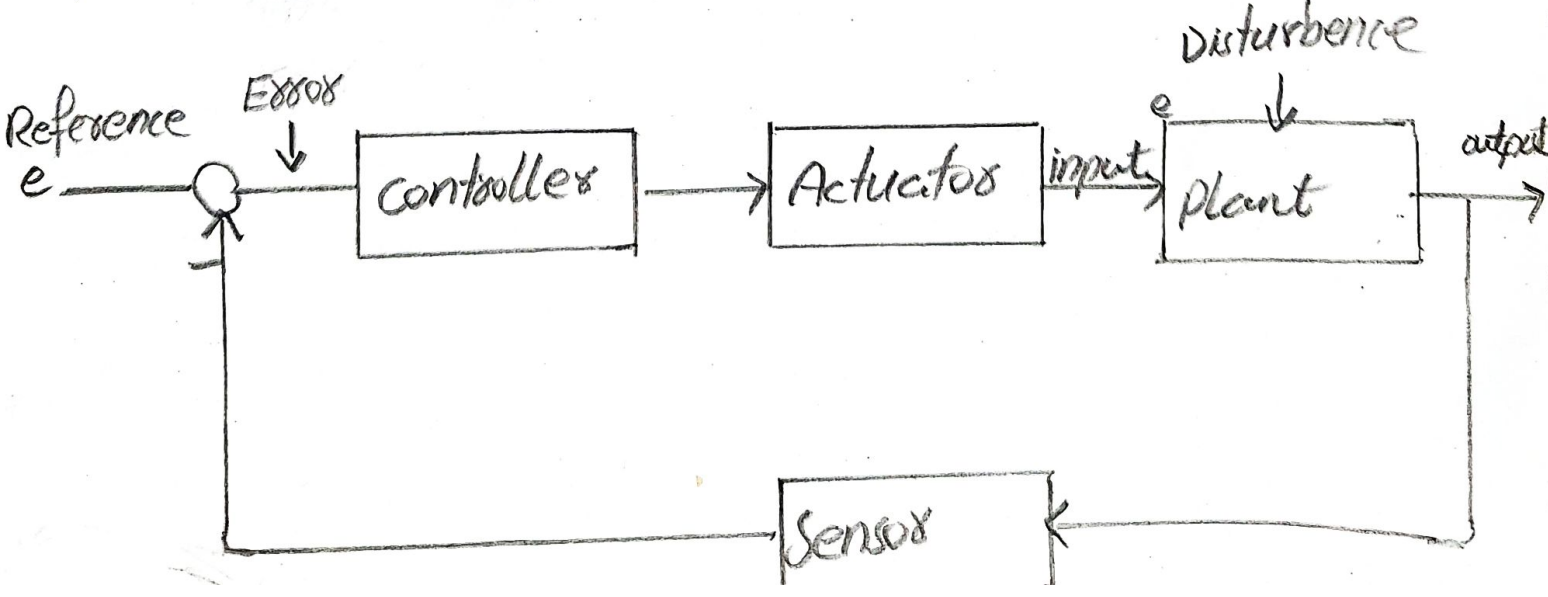
* Make connection based on the error
* The sensor & the actuator are key elements of a feedback loop
* Design control alogorithm.



Example:-

Automobile Direction control

* Attempts to change the direction of the automobile



* Manual closed-Loop control.
* Although the controlled system is "Automobile", the input & the output of system can be different depending on control objectives.

The Major Advantages ~~& Disadvantage~~ of Open-Loop Control System.

① Simple construction & ease of maintenence
② Less expensive than a corresponding closed-Loop system
③ There is no stability problem
④ Convenient when output is hard to measure or measuring the output precisely is economically not feasible. For example, in the washer system it would be quite expensive to provide a device to measure the quality of the washer's output cleanliness of the clothes.

The Major Disadvantages of open-Loop control system.

① Disturbence & changes in calibration cause errors, and the output may be different from what is desired.

(2) To maintain the required quality in the output recalibration is necessary from time to time

Q#2 Find Laplace Transform of

(i) $f(t) = t^n$

$$L\{f(t)\} = \int_0^\infty e^{-st} f(t)\,dt \quad \text{——(I)}$$

$$L\{t^n\} = \int_0^\infty e^{-st} t^n\,dt$$

Let $st = x$

$$L\{t^n\} = \int_0^\infty e^{-x} t^n\,dt$$

$\therefore \quad st = x$

$$t = x/s$$

$$L\{t^n\} = \int_0^\infty e^{-x} \left(\frac{x}{s}\right)^n d\left(\frac{x}{s}\right)$$

$$= \int_0^\infty e^{-x} \left(\frac{x^n}{s^n}\right) d\left(\frac{x}{s}\right)$$

$$= \int_0^\infty e^{x} \frac{x^n\,dx}{s^n . s}$$

$$= \int_0^\infty \frac{e^x x^n\,dx}{s^n . s}$$

$$= \int_0^\infty \frac{e^x x^n\,dx}{s^{n+1}}$$

$$L\{t^n\} = \frac{1}{s^{n+1}} \int_0^\infty e^{-x} x^n\,dx \quad \text{——II}$$

$\therefore \int_0^\infty e^{-x} x^n dx = \sqrt{x+1}$ put in eq II

$$\mathcal{L}\{t^n\} = \frac{1}{s^{n+1}} \sqrt{n+1}$$

$$= \frac{\sqrt{n+1}}{s^{n+1}}$$

$$\boxed{\mathcal{L}\{t^n\} = \frac{n!}{s^{n+1}}}$$

(ii) $f(t) = e^{at}$

Sol:-

Formula

$$\mathcal{L} f(t) = \int_0^\infty e^{-st} f(t)\, dt$$

$$\mathcal{L}\{e^{at}\} = \int_0^\infty e^{-st} e^{at}\, dt$$

$$\mathcal{L}\{e^{at}\} = \int_0^\infty e^{-st+at}\, dt$$

$$= \int_0^\infty e^{-t(s-a)}\, dt$$

$$= \frac{e^{-t(s-a)}}{-(s-a)} \Big|_0^\infty$$

$$= -\frac{1}{s-a}\left[e^{-t(s-a)}\right]_0^\infty$$

$$= -\frac{1}{s-a}\left[e^{-\infty(s-a)} - e^{-0(\infty-a)}\right]$$

$$= -\frac{1}{s-a}\left[e^{-\infty} - e^{-0}\right]$$

$$= \frac{-1}{s-a}\left[e^{-\infty} - e^{0}\right]$$

$\because e^{-\infty} = 0 \;\{\; e^0 = 1$

$$= \frac{-1}{s-a}\left[0-1\right]$$

$$= \frac{-1}{s-a}(-1)$$

$$= \frac{1}{s-a}$$

$$\boxed{\mathcal{L}\{e^{at}\} = \frac{1}{s-a}}$$

(iii) $f(t) = \sin at$

Sol:-

As $\mathcal{L} f(t) = \int_0^\infty e^{-st} f(t)\, dt$

So $\mathcal{L}\{\sin(at)\} = \int_0^\infty e^{-st} \sin(at)\, dt$

$$\therefore \int e^{ax} \sin bx\, dx = \frac{e^{ax}}{a^2+b^2}\left[a\sin(bx) - b\cos(bx)\right]$$

Here $a = -s$, $b = a$ & $x = t$

$$\mathcal{L}\{\sin(at)\} = \frac{e^{-st}}{(-s)^2+a^2}\left[-s\sin(at) - a\cos(at)\right]_0^\infty$$

$$= \left[\frac{e^{-st}}{s^2+a^2}\cdot(-s\sin(at)) - \frac{e^{-st}}{s^2+a^2}(a\cos(at))\right]_0^\infty$$

Apply limits

$$= \left[\frac{e^{-s(\infty)}}{s^2+a^2}\cdot[-s\sin(a\infty) - \frac{e^{-s(\infty)}}{s^2+a^2}\cdot a\cos(a\infty)\right] -$$

$$\left[\frac{e^{s(0)}}{s^2+a^2}\cdot[-s\sin(a\cdot 0) - \frac{-e^{-s(0)}}{s^2+a^2}\cdot a\cos(a\cdot 0)\right]$$

$$= \left[\frac{e^{-\infty}}{s^2+a^2}\cdot[-s\sin(\infty)] - \frac{e^{-\infty}}{s^2+a^2}[a\cos(\infty)]\right] -$$

$$\left[\frac{e^{0}}{s^2+a^2}\cdot[-s\sin(0)] - \frac{e^{0}}{s^2+a^2}[a\cos(0)]\right]$$

$\therefore e^{\pm\infty} = 0 \qquad e^0 = 1$

$$= \left[0 \cdot [-\sin(\infty)] - 0\,[a\cos(\infty)]\right] - \left[\frac{1}{s^2+a^2} \cdot (-\sin(0)\right.$$

$$\left. - \frac{1}{s^2+a^2} \cdot (-s\sin(0) - \frac{1}{s^2+a^2}(a\cos(0)\right]$$

$$= [0-0] - \left[\frac{1}{s^2+a^2} \cdot (0) - \frac{1}{s^2+a^2}(a) \cdot 1\right]$$

$$= - \left[\frac{-a}{s^2+a^2}\right] \quad OR \Rightarrow \frac{a}{s^2+a^2}$$

$$\mathcal{L}\{\sin(at)\} = \frac{a}{s^2+a^2}$$

(iv) $\mathcal{L}\{\cos(3t)\}$

Sol

$$\mathcal{L}\{f(t)\} = f'(s)$$

$$\mathcal{L}\{\cos(3t)\} = f'(s) \quad \text{---} (1)$$

As $\mathcal{L}\{\cos(at)\} = \frac{s}{s^2+a}$ put it in eq (1)

$\mathcal{L}\{\cos(3t)\} = \frac{s}{s^2+3^2}$ $\therefore$ $a = 3$, $t = s$

$$\boxed{\mathcal{L}\{\cos(3t)\} = \frac{s}{s^2+9}}$$

(v) $\mathcal{L}\{e^{-5}t^5\}$

Sol:-

$\mathcal{L}\{f(t)\} = f'(s)$

$\mathcal{L}\{t^{+5}\} = \frac{5!}{s^{5+1}}$

$\therefore \mathcal{L}(t^n) = \frac{n!}{s^{n+1}}$

$\mathcal{L}\{t^5\} = \frac{120}{s^6} = f'(s)$

By shifting property

$\mathcal{L}\{e^{-t}t^5\} = f'(s-a)$

So, $f'(s) = \frac{120}{s^6}$

$f'(s-a) = \frac{120}{(s-a)^6}$

Here $a = -1$

$f'(s-a) = \frac{120}{\{s-(-1)\}^6}$

$f'(s-a) = \frac{120}{(s+1)^6}$

OR

$$\mathcal{L}\{e^{-t}t^5\} = \frac{120}{(s+1)^6}$$

(vi) $\mathcal{L}\{t\sin(3t)\}$

Sol:-

As we know

$$\mathcal{L}\{f(t)\} = f'(s)$$

Here $\mathcal{L}\{f(t)\} = \mathcal{L}\{\sin(3t)\}$

$\because \mathcal{L}\{\sin(3t)\} = \frac{3}{s^2+9}$ $\quad \because \mathcal{L}\sin(at) = \frac{a}{s^2+a}$

As $f'(s) = \mathcal{L}\{\sin(3t)\}$

$$f'(s) = \frac{3}{s^2+9}$$

Now by multiplying t property

$$\mathcal{L}\{t.\sin(3t)\} = \frac{-d}{ds} f'(s)$$

putting value of $f'(s)$

$$\mathcal{L}\{t.\sin(3t)\} = \frac{-d}{ds}\left(\frac{3}{s^2+9}\right)$$

$$= -\left[\frac{(s^2+9)\frac{d}{ds}(3) - 3\frac{d}{ds}(s^2+9)}{(s^2+9)^2}\right]$$

$$= -\left[\frac{(s^2+9)(0) - 3(2s+0)}{(s^2+9)^2}\right]$$

$$= -\left[\frac{0 - 6s + 0}{(s^2+9)^2}\right]$$

$$= -\left[\frac{-6s}{(s^2+9)^2}\right]$$

$$\boxed{\mathcal{L}\{t \cdot \sin(3t)\} = \frac{6s}{(s^2+9)^2}}$$

(viii) $\mathcal{L}\left\{\frac{(1-\cos t)}{t}\right\}$

Sol

$\mathcal{L}\{1-\cos(t)\} = t$

$= \mathcal{L}(1) - \mathcal{L}\{\cos(t)\}$

$= \frac{1}{s} - \frac{s}{s+1}$

$= f'(s)$

By using t proprties

$\mathcal{L}\left\{\frac{f(t)}{t}\right\} = \int_0^\infty f'(s)\,ds$

$= \int_0^\infty f\left(\frac{1}{s} - \frac{s}{s^2+1}\right) dt$

$= [\log s - \frac{1}{2}\log(s^2+1)]$

$= \frac{1}{2}[\log s - \log(s^2+1)]$

$= \frac{1}{2}\left[\log \frac{s^2}{s^2+1}\right]_0^\infty$

$= \frac{1}{2}\left[\lim_{s\to\infty} \log\left(\frac{s^2}{s+1}\right) - \log\left(\frac{s^2}{s^2+1}\right)\right]$

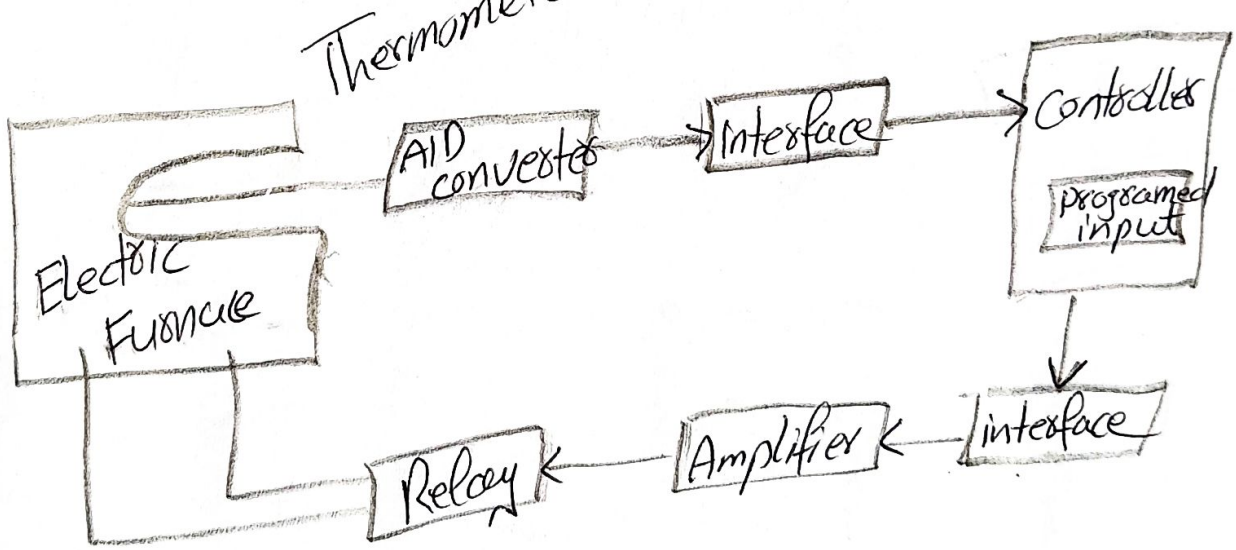
$= \frac{1}{2}\left[\lim_{s\to\infty} \log\left(\frac{s^2}{1+\frac{1}{s^2}}\right) - \log\left(\frac{s^2}{(s^2+1)}\right)\right]$

$= \frac{1}{2}\left[\log 1 - \log\left(\frac{s^2}{s^2+1}\right)\right]$

$\boxed{= -\frac{1}{2}\log\left(\frac{s^2}{s^2+1}\right)}$

→ Temprature Control System-

The temprature of electric furnace is measure by thermometer which is an analog device. The analog ~~device~~ temprature is converted into digital temprature by A/D convertor. The digital temprature is compared with the programed input temprature & if there is any discrepancy (error) the controller send out out a signal to the heater through interface amplifier & relay to bring the furnace temprature to desired value



Speed Control System

The basic principle of watt's governor schematic diagram. The amount of fuel admitted to engine adjusted according to difference between ~~speed~~ desired & actual engine speed.

In this speed control system the plant (control system is the engine & controlled variable, is the speed of engine. The difference between desired speed and actual speed is error signal. The control signal (The engine) is the actuating signal. The external input is to disturb the controlled variable is disturbance. An unexpected change in the load is a disturbance.

Diagram