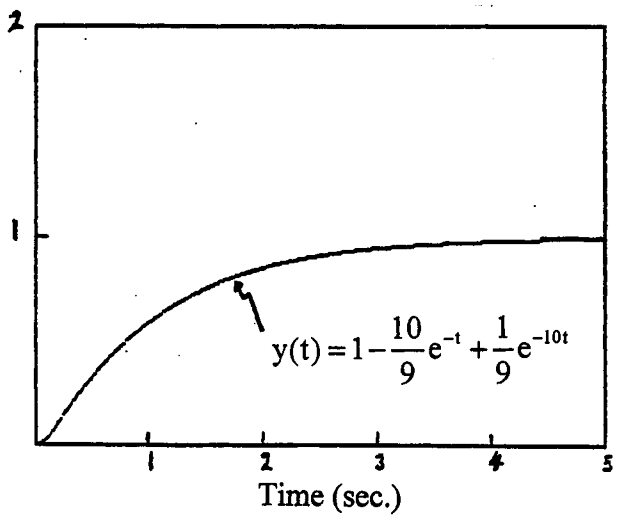
(16%)1. Consider the following dynamic system:

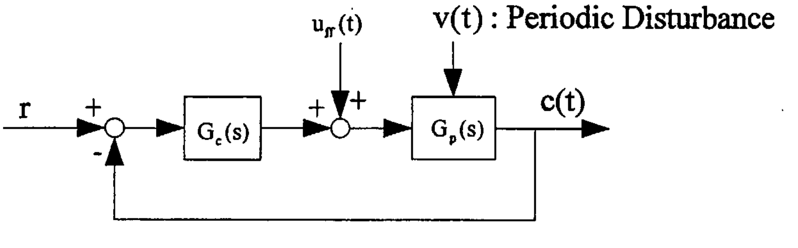
$$\frac{d}{dt}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} -0.1 & 1 \\ 0 & -1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u(t)$$
$$y(t) = x_1(t)$$

a) Find the input output transfer function. (8%)

b) Find the input function $u(t)$ which will result in a response $y(t)$ as shown in the following figure when $\underline{X}(0) = \underline{0}$. (8%)



(10%)2. A linear plant, $G_p(s)$, is under linear feedback control. The controller $G_c(s)$ has been selected so that the closed loop system is asymptotically stable and that the steady state error for a constant reference input is zero if no disturbance exists. Because of an unmeasurable periodic disturbance, $v(t)$, it has been noted that the steady state measured plant output is $c(t) = r + d \cdot \sin(\omega_d t)$ where r is the constant set point and $d \cdot \sin(\omega_d t)$ is the disturbance dependent term. Our proposal is to inject a signal $u_{ff}(t)$ for canceling the disturbance effect. Determine $u_{ff}(t)$ which will make the steady state measured output be $c(t) = r$ under the existence of the same disturbance. d and ω_d are already available.



(24%) 3. For each of the outputs sketched below indicate the (input, transfer function) combination(s) that would produce that output.

Note: There can be more or less than one combination to produce each output.

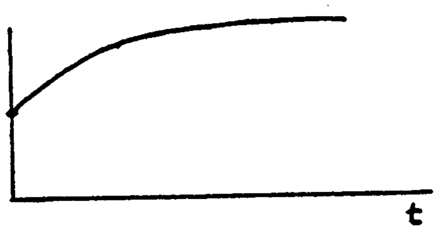
Inputs:
- A. unit step
- B. unit ramp
- C. unit impulse

Transfer functions:

I. $\dfrac{1}{s+1}$; II. $\dfrac{s}{s^2+3s+2}$; III. $\dfrac{s+1}{s+2}$;

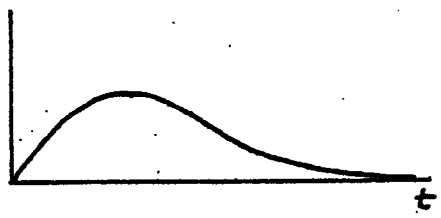
IV. $\dfrac{1}{s^2+s+2}$; V. $\dfrac{1}{s^2+3s+2}$; VI. $\dfrac{s+1}{s+0.5}$.

a)

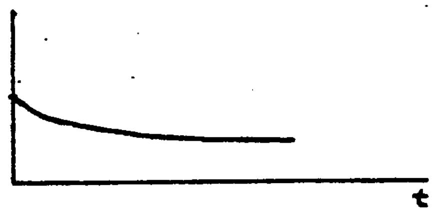


b)

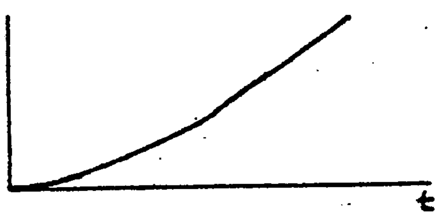
c)



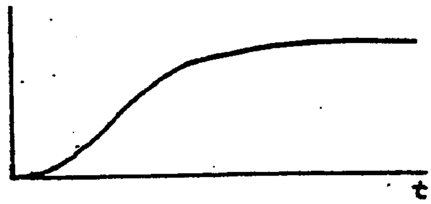
d)



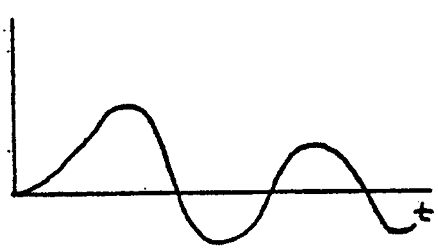
e)



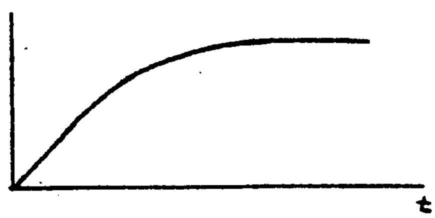
f)



g)



h)



4. a) If an input signal of a control system is $A \sin \omega t$, what kind of the signal is the output signal at the steady state response, if the transfer function of the control system is G(s)? please derive it and explain it. (7%)

b) Explain the meaning of the bandwidth in Bode plot ? How about the system response speed, if the bandwidth of a system is wider (or larger) than the other, please explain it with mathematical model, if you could. (7%)

5. a) Explain the Nyquist stability criterion ? Using the following case: if a unit feed back control system, which open loop transfer function has no poles in the right hand side s-plane, how to judge the stable condition of a feedback control system ? (8%)

b) Consider a unit feedback control system, when the open loop transfer function

$$G(s) = \frac{K}{s(\tau_1 s+1)(\tau_2 s+1)},$$

determine the necessary K value for the stability of the above feedback control system? (10%)

6. A control system for a chemical concentration control system is shown in the following figure, the system receives a granular feed of varying composition, and we want to maintain a constant composition of the output mixture of the tank and output valve is $G(s) = \frac{5}{5s+1}$,

and that of the controller is $G_c(s) = K_1 + \frac{K_2}{s}$

The transport of the feed along the conveyor requires a transport time T=1.5 sec.

a) sketch the Bode diagram when $K_1 = K_2 = 1$ and investigate the stability of the system ? (10%)

b) May you explain the effect of the delayed transport time from Bode diagram? (8%)