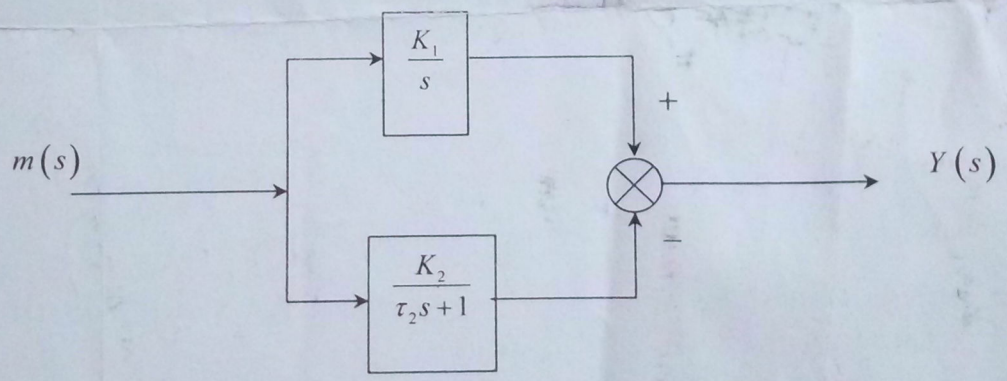
c) A unity feedback system with forward path transfer function $G(s) = \dfrac{K}{s(\tau_1 s + 1)(\tau_2 s + 1)}$. What value of K will give the stable response?

d) Develop the compensator in a feedback control loop for the process represented by following block diagram:



(4×2.5 marks)

Department of Chemical Engineering, Indian Institute of Technology, Delhi

Subject: CHL261 (Instrumentation and Process Control)

Major (40 Marks), Duration: 2 hr (Open Book: Chemical Process Control by George Stephanopolous & Process System Analysis and Control by Donald Coughanowr)

SOLVE ANY FOUR QUESTIONS

1) The open loop transfer function of a negative feedback control system is given by $G_{OL}(s) = \dfrac{K(s+1)}{s^2(0.316s+1)}$

Determine analytically:

a) Possible maximum phase margin and the frequency at which it occurs.

b) What should be the gain K for this phase margin? **(5+5 marks)**

2) A unity feedback control system has an open loop transfer function $G_{OL}(s) = \dfrac{K(s+1)}{s(s-1)}$.

a) Show analytically that the root loci of complex roots are part of circle with (-1, 0) as centre and radius $= \sqrt{2}$ (**Hint:** Make use of angle criteria).

b) Sketch the root locus with K as a variable parameter **(5+5 marks)**

3) A feedback control system has PI controller with transfer function $G_c(s) = 0.4\left(1 + \dfrac{1}{0.4s}\right)$ to control the process $G_p(s) = \dfrac{1}{(s+0.6)}$. Assume $G_f(s) = G_m(s) = 1$.

For the given system determine:

a) Natural frequency

b) Damping factor

c) Time constant

d) Overshoot

e) Decay ratio **(5×2 marks)**

4) Liquid flows into a tank at the rate of F_i m^3/s. The tank has three vertical walls and one slopping outward at an angle β to the vertical. The base of the tank is a square with sides of length x m and the average operating level of liquid in the tank is Z_0 m. If the relationship between liquid level and flow out of the tank at any instant is linear, develop an expression for the time constant for the system. (**Hint:** Use the appropriate expression for volume. Use Taylor series for linearization)

(10 Marks)

5) Solve following sub questions:

a) If the transfer functions for process, disturbance, disturbance measurement and final control element are: $G_p(s) = \dfrac{2e^{-0.3s}}{0.5s+1}$, $G_d(s) = \dfrac{1}{0.7s+1}$, $G_{md}(s) = 0.8$ and $G_f(s) = 0.9$, what will be the transfer function for perfect feed-forward controller? Is it possible to build this feed-forward controller?

b) What overall transfer function $G(s) = \dfrac{C(s)}{R(s)}$ is expected for following system: