

# GATE.CH.61

EE23BTECH11062 - V MANAS

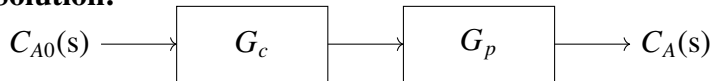
## Question:

The outlet concentration  $C_A$  of a plug flow reactor (PFR) is controlled by manipulating the inlet concentration  $C_{A0}$ . The following transfer function describes the dynamics of this PFR.

$$\frac{C_A(s)}{C_{A0}(s)} = e^{-(\frac{V}{F})(k+s)}$$

In the above question,  $V=1m^3$ ,  $F=0.1m^3min^{-1}$  and  $k=0.5min^{-1}$ . The measurement and valve transfer functions are both equal to 1. The ultimate gain, defined as the proportional controller gain that produces sustained oscillations, for this system is (GATE 2023 CH 61)

## Solution:



Variable	Description	Values
$G_o$	overall transfer function	1
$G_p$	process transfer function	$G(s)$
$G_c$	proportional controller transfer function	$K_c$

TABLE I  
VARIABLES USED

$$G(s) = \frac{C_A(s)}{C_{A0}(s)} = e^{-(\frac{V}{F})(k+s)} \quad (1)$$

$$G(s) = e^{-(\frac{1}{0.1})(0.5+s)} \quad (2)$$

$$G(s) = e^{-(10s+5)} \quad (3)$$

The transfer function of a proportional controller is  $K_c$  so we can take,  $G_c=K_c$

Given that the measurement and valve transfer functions are both equal to 1, we can take  $G_p=G(s)$

$$G_o = G_p \times G_c \quad (4)$$

$$G_o = G(s) \times K_c \quad (5)$$

$$1 = e^{-(10s+5)} \times K_c \quad (6)$$

$$1 = 1 \times \frac{K_c}{e^5} \quad (7)$$

$$\therefore K_c = e^5 = 148.11$$