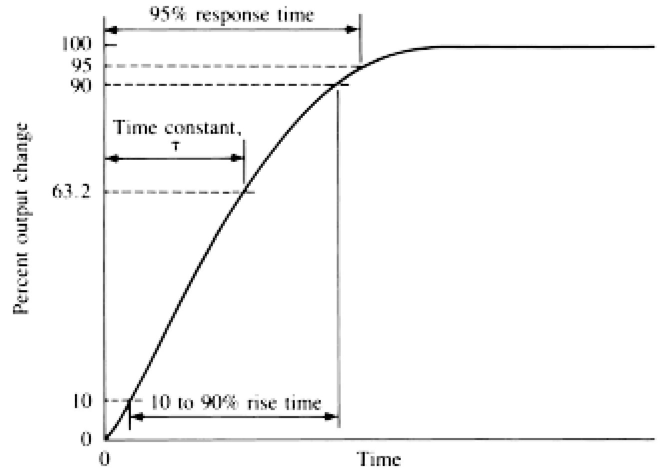
Question 1:

a) Given a step response of a critically damped system, how to determine the time constant "t" and the rising time of the system? (10 Marks) (PAGE 164)



Time Constant - "The time required for the output of a component to reach 63.2% of the total change after a step change in input." (PAGE 164)

Rise Time – "The time required for the output to go from a small percentage of change to a larger percentage of change, after a step change in input. Unless otherwise specified, the change is from 10% to 90%"

Response time – "The time required for the output to reach a designated percentage of the total change, after a step change in input."

b) Why is a voltage follower required in a measuring instrument with a primary sensing unit and an amplifier? (10 Marks) (PAGE 191)

*Voltage Follower – "*A circuit with a very high input impedance, a very low output impedance, and an output voltage that is equal to the input voltage."

A voltage follower has the same output voltage as input voltage and is used so that the primary sensor sees only the input impedance of the "op amp". The effect of the voltage follower is to increase the impedance as seen by the primary sensor. The voltage follower is used to allow the amplifier to see the output impedance of the "op amp" because a low source impedance is good for an amplifier.

c) Determine the time-domain function f(t) from the following frequency-domain function: (10 Marks) (PAGE 134 EXAMPLE)

$$F(s) = \frac{s+1}{(s+2)^2}$$

Determine the transfer function:

$$\frac{s+1}{(s+2)^2} = \frac{A}{(s+2)} + \frac{B}{(s+2)^2}$$

$$s + 1 = A(s+2) + B; \qquad Multiply\ everything\ by\ (s+2)^2$$

Set s=(-2) to find B, then set s=(0) to find A:

$$A = 1\ \&\ B = -1$$

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

$$= 1e^{-2t} - 1te^{-2t}$$

d) The PID controller is described by the following equation: (10 Marks) (ASSIGNMENT QUESTION)

$$v = 3e + 0.05\frac{de}{dt} + 1.2\int e\,dt$$

where e is the input error and v is the controller output. Determine the transfer function:

$$V(s) = 3E(s) + 0.05\big(sE(s) - e(0)\big) + \frac{1.2E(s)}{s}$$

The e(0) is equal to zero

$$V(s) = 3E(s) + 0.05sE(s) + \frac{1.2E(s)}{s}$$

$$\frac{V(s)}{E(s)} = \frac{0.05s^2 + 3s + 1.2}{s}$$

Question 2:

The following figure illustrates a closed-loop control system. Determine the transfer functions of (cm/sp) and (c/sp). (15 Marks)

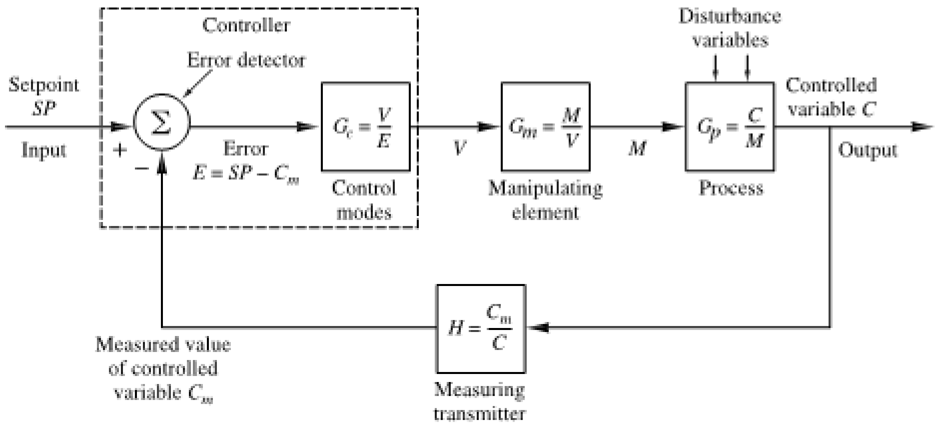


Figure 1: Figure 1.7 from Page 9 of the book

First write the transfer function of (G) is the product of all three component transfer functions

$$G = G_C G_m G_p$$

Write the error equation

$$E = SP - C_m$$

Second, we use the overall forward transfer function, G, to write the following equation for the controlled variable, C.

$$C = EG$$

Third, we write the following equation for Cm.

$$C_m = CH$$

Fourth, we use substitution to eliminate C and E.

$$C_m = EGH$$

$$C_m = (SP - C_m)GH$$

Finally, we solve the above equation for the ratio Cm/SP.

$$\frac{C_m}{SP} = \frac{GH}{1 + GH}$$

Question 3:

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Question 4:

A measuring instrument has a transfer function of: (30 Marks)

$$H(s) = \frac{X(s)}{C(s)} = \frac{2.02}{s^2 + 2s + 101}$$

Determine the following: (PAGE 138 Example)

a) The frequency domain response X to a step change in input, C, from 0°C to 100°C.
b) Determine the roots of the denominator of the resulting function.
c) Determine the time-domain expression, x, for the step response.