ORDRE DES INGÉNIEURS DU QUÉBEC

MAY 2013 SESSION

Open-book examination
Calculators : only authorized models
Duration : 3 hours

04-CHIM-A6 PROCESS DYNAMICS AND CONTROL

Question 1. **(15 points)**

Answer the following questions and justify your answer:

a) What are the parameters of a first order process and their significance?

b) Why is a PID controller not recommended when there is a lot of signal noise in the measurements?

c) Does a larger gain margin make the closed loop response of a process faster or slower? Why?

d) What is an inverse response, and what causes it?

e) For a system with feedback-feedforward controllers, does the adjustment of the feedforward affect the stability characteristics of the process? Why?

Question 2. **(30 points)**

A 3 tanks configuration is shown on Figure 2.1.

F_1, F_2, F_3, F_4, F_5 are volumetric flow rates (in m^3/h).
A_1, A_2 , A_3 are tank surface areas (in m^2).
h_1, h_2, h_3 are tank liquid levels (in m).

Flow rates F_2 , F_3 and F_4 are proportional to the hydrostatic pressure causing the flow. F_5 is constant and is independent of h_3.

Find the transfer function between F_3 and F_1.

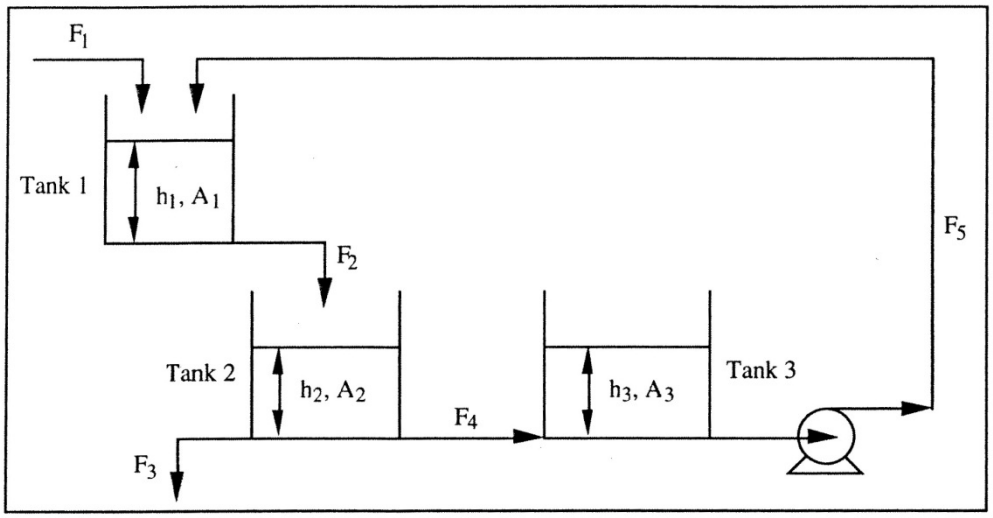

Figure 2.1

Question 3. **(15 points)**

The dynamic behavior of a physical process can be represented by the transfer function :

$$\frac{y(s)}{x(s)} = \frac{18}{s^2 + 3s + 9}$$

a) After a step change in the input *x* of magnitude 3, what is the new steady-state value of *y* ?

b) If the maximum allowable value of *y* is 10, what is the largest step change in *x* permitted?

Question 4. **(20 points)**

A process (including valve and measure element) have the following transfer function:

$$G(s) = \frac{3\, e^{-0.15s}}{5s + 1}$$

Calculate the proportional constant (K_c) of a PI controller if :

$\tau_i = \tau_p$
gain margin = 2

Hint :

Trigonometric identity : $\tan^{-1}(x) = \pi/2 - \tan^{-1}(1/x)$
$\tan^{-1}(-x) = -\tan^{-1}(x)$

Question 5. **(20 points)**

A closed loop process is presented in Figure 5.1.

a) Using Routh criteria, for what range(s) of τ_m the resulting system be stable ?

b) What practical argument might be used to restrict the range(s) of acceptable τ_m even further ?

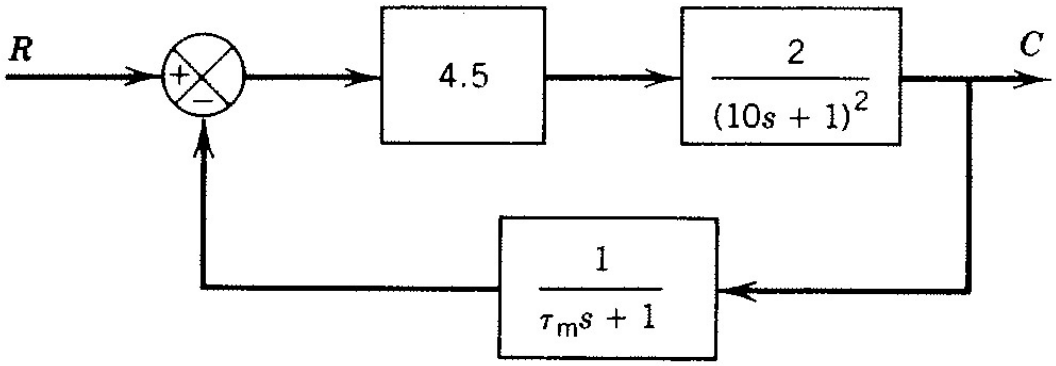

Figure 5.1