Surname:__________ Name:__________ Student code:__________

There is no need,
and actually, it is NOT allowed using the scientific calculator to make this test

Section 1: QUIZ

1) 1. The time constant τp of a 1st order system coincides with the time required for the step response to reach 50% from the final value

True False

2) The damping factor of a 2nd order system can also be negative

True False

3) The IAE calibration formula minimizes the integral of the error module

True False

Section 2: QUIZ

1. Which one of the following definitions does not apply to a **feedback controller**?

a. "direct action"
b. "reverse action"
c. a relay
d. FOPDT

2. The PI controller transfer function is

a. $G_c=K_c[1+ \tau_I s]$
b. $G_c=K_c[1+1/(\tau_I s)]$
c. $G_c=K_c[1/(1+\tau_I s)]$
d. $G_c=K_c/(\tau_I s)$

3. Which of the following "parameters" is not included in the 2nd order system law?

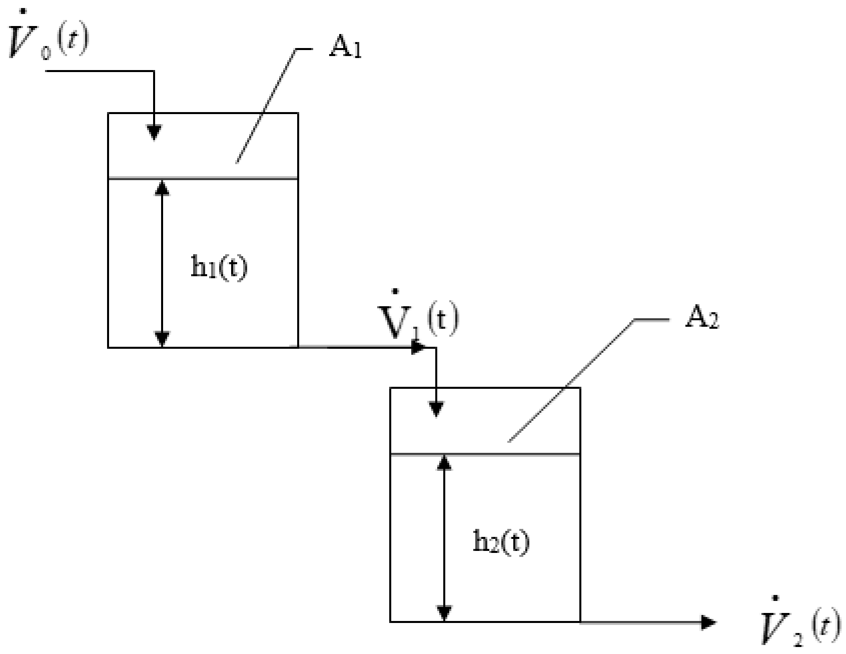
a. Process gain
b. *overshoot*
c. Natural oscillation period
d. Damping factor

4. The offset is:

a. $y_\infty - y_{SP}(t)$
b. $y_{SP}(t) - y_\infty$
c. $y_\infty - y_m(t)$
d. Always positive

Section 3: DYNAMIC REFERENCE MODELS

3.1. Dynamic response of 2nd order



The system in the figure is formed by the two tanks in series operating each with a linear relationship between the output flow rate and the liquid level, with the following additional data:

$A_1 = 2\ m^2$ $A_2 = 1\ m^2$ $R_1 = 1.5\ m/(m^3/min)$ $R_2 = 3\ m/(m^3/min)$

a) What is the time constant of each tank?

b) What is the static gain of each tank?

At steady state, the input flow rate is constant: $\dot{V}_{0s} = 1\ m^3/min$.

At time t = 0, the input flow rate into the first tank $\dot{V}_0(t)$ is sharply raised to 1.5 m^3/min and then remains constant on such a new value. You want to know as a result of this change:

c) how much the total variation will be in height of the 1st tank for a long time

d) how long the level change of 1st tank takes to reach 95% of final variation

e) how much the total variation will be in height of the 2nd tank for a long time

f) how long the 2nd tank takes to reach 70% of its level variation

NB:
to answer these questions, you are asked to make use of the following generalized diagrams of the dynamic response and NOT to employ FORMULAS !

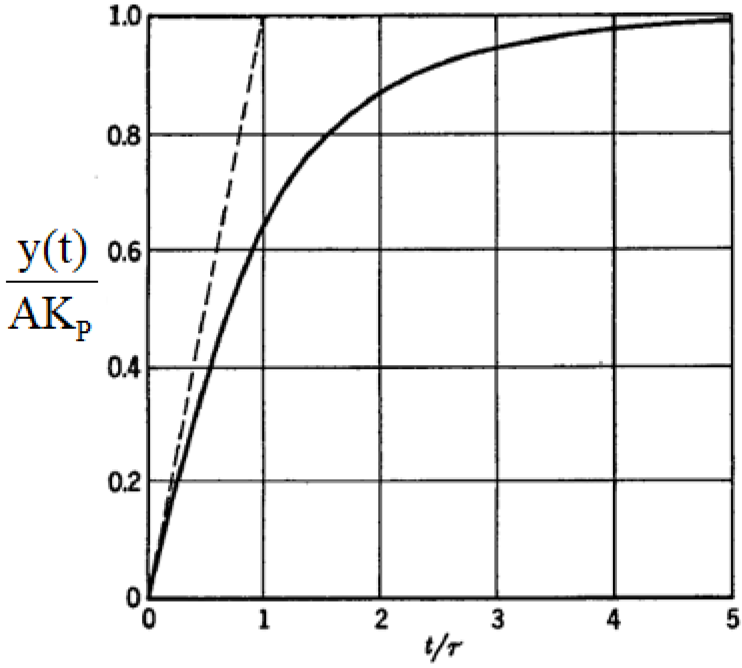
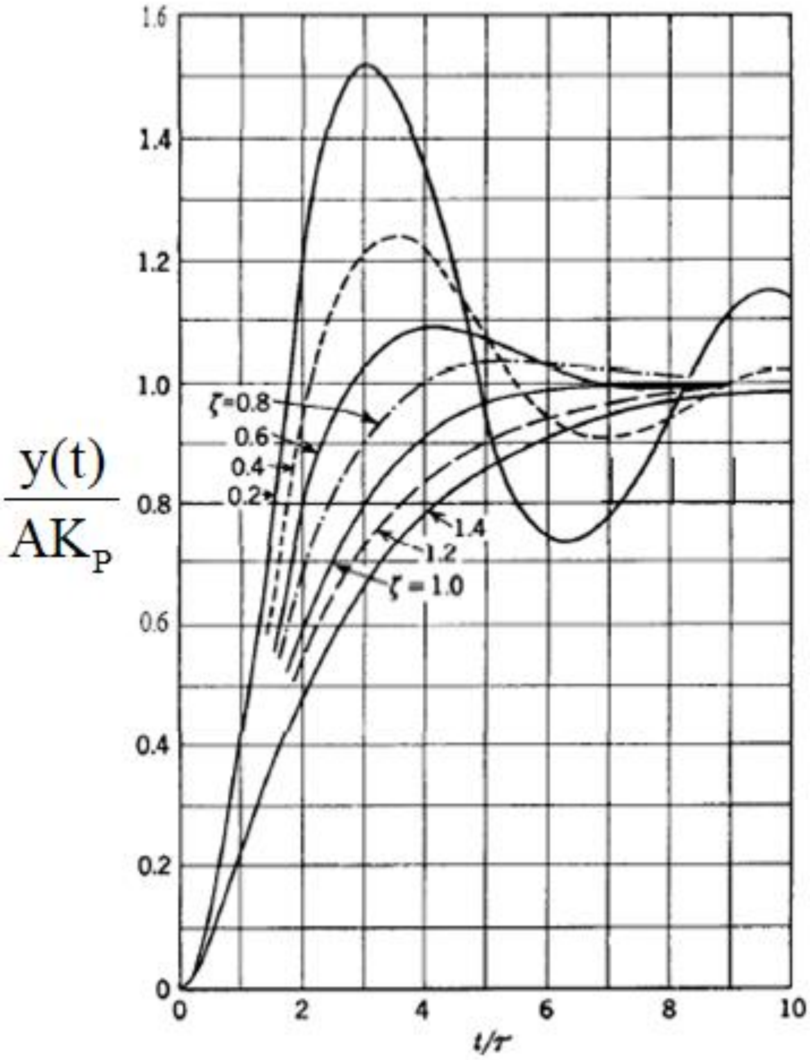


FIGURE 5-6
Response of a first-order system to a step input.



3.2. Poles and zeros of a transfer function

For the following **Transfer Function**

$$G(s) = \frac{s^2 + 1}{s^3 + 3s^2 + 2s}$$

a) calculate the zeros of this TF

b) calculate the poles of this TF

c) draw the complex plane, and places each of the poles on it

For each of the poles

d) provide the mathematical contribution it gives to the dynamic response in the time domain

e) provide its stability properties in the time domain

3.3. FOPDT Model

a) How many and what are the characteristic parameters?

b) What is the transfer function

c) Is it a linear model?

d) Some people define it as a **series system**: Why? Which dynamic reference models do make it?

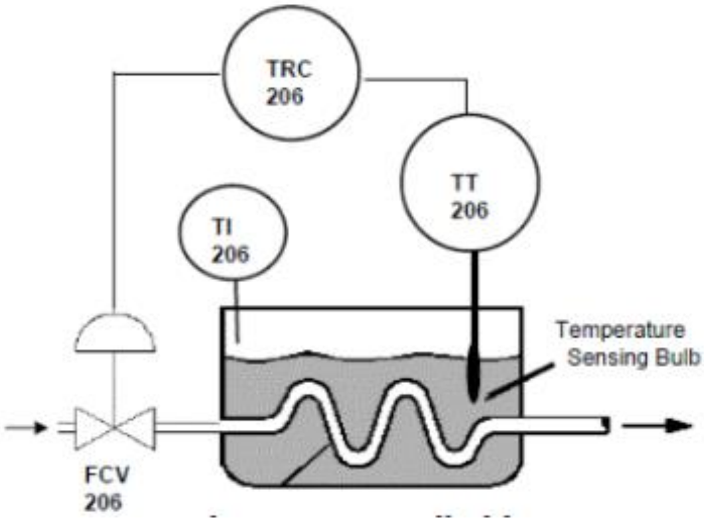
e) In the case of a FOPDT INTEGRATING model, how many and what are the characteristic parameters?

f) Also in the case of a FOPDT INTEGRATING model, what is the transfer function?

Section 4: PROCESS CONTROL

4.1. *Feedback* control

The figure introduces a practical application of feedback control by means of a simplified P&ID.



Among the various variables (flow rate, etc.)

a) select the **controlled variable**:

b) select the **manipulated variable**:

c) select the **disturbance variable** (if any):

d) Define the role that each control **block component** has in the Feedback Block Diagram, and that is specific to the case in question

1) liquid tank:

2) pipe:

3) valve FCV 206:

4) TI 206:

5) TT 206:

6) TRC 206:

~~**e)** What kind of **signals** is used for communication in this case of ***feedback* control**?~~

Section 5: CONTROLLERS

5.1. The relay controller

a) draw the **error** ε(t) – *controller output* o(t) diagram in presence of **hysteresis**

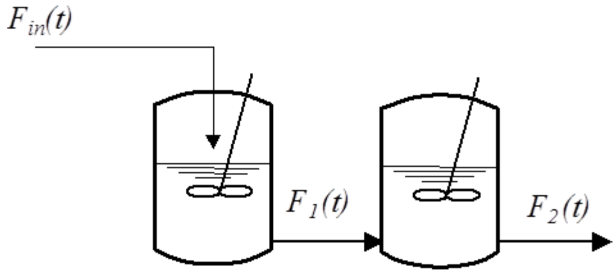
b) explain briefly what **hysteresis** is

c) provide an application example of a ***relay*** **controller**

Section 6: MATHEMATICAL MODELS

6.1. Development of a dynamic mathematical model for a lumped parameter system

With ref. to the dynamic system corresponding to the case in figure:



under the **hypotheses** of

- linear outflow relationship
- isothermal operation

a. determine the overall **transfer function** $G_{ov}(s) = h_2(s)/F_{in}(s)$

b. determine the **transfer function** of the 1st tank $G_1(s) = h_1(s)/F_{in}(s)$