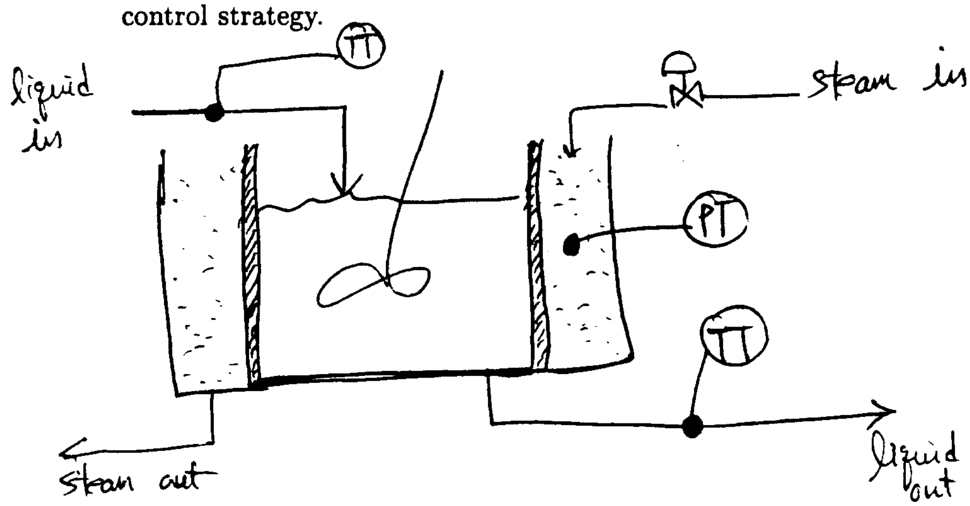
1. Discuss the hardware elements of *digital* process control implementation. List at least three advantages of digital implementation over the traditional pneumatic or electronic (analog) implementation.

2. Draw the schematic of the *best control strategy* for the following continuous stirred tank heater. The main disturbances are the inlet temperature and the steam supply pressure. Measurements of the inlet temperature, tank outlet temperature and steam pressure are assumed to be available for control. The tank wall is thick enough that its thermal capacitance is significant. Note that I am not asking you to develop a model, but simply draw in the best control strategy.



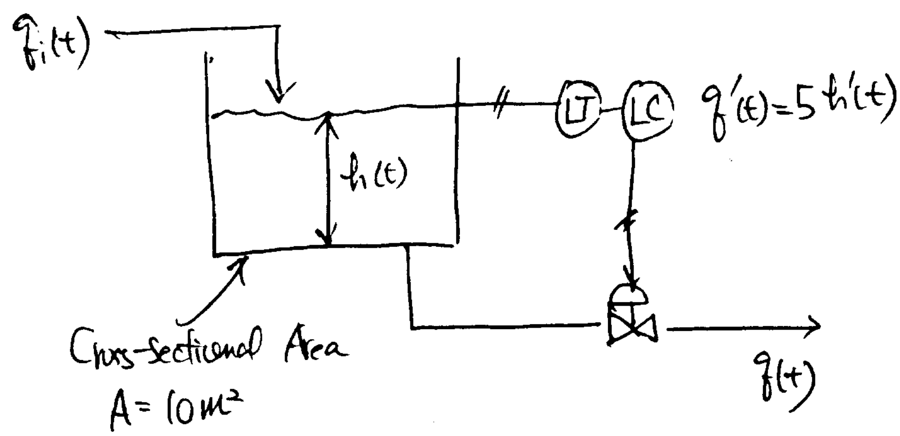
Controlled Variable:
Outlet temperature

3. Why does the Fourier transform of an impulse response give the frequency response information? How would you obtain the amplitude ratio and the phase angle, given an experimental output response to an input other than an impulse?

4. Consider the following tank storage system:

$q_i'(t) = q_i(t) - \bar{q}_i$
$q'(t) = q(t) - \bar{q}$
$h'(t) = h(t) - \bar{h}$

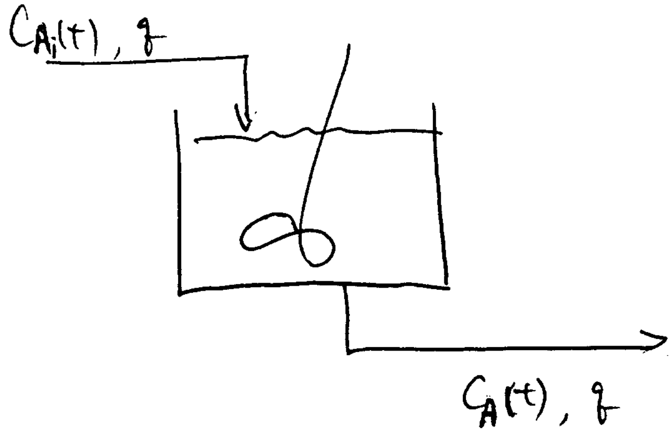
$\bar{q}_i = 10 m^3/min$
$\bar{q} = 10 m^3/min$
$\bar{h} = 10 m$



Suppose the control law for the level-loop is given by $q' = 5h'(t)$. Compute the transfer function $\hat{h}'(s)/\hat{q}_i'(s)$ and the response $h'(t)$ when there is a step change in $q_i'(t)$ of size $2m^3/min$.

SAMPLE MIDTERM

5. The following is a well-mixed tank. Normally the tank inlet and outlet are pure water. Suppose one injects a tracer material of $2 kgmols$ at $t = 0$. Compute the expression for the concentration of the tracer at the outlet of the tank.



$q = 2 m^3/min$

$\bar{C}_{Ai} = \bar{C}_A$

$V = 20 m^3$

$C_A(t) = ?$

6. Match the transfer functions on the left-hand side with the step responses on the right-hand side:

$$\frac{8s+2}{10s^2+7s+1}$$

$$\frac{16s+2}{10s^2+7s+1}$$

$$\frac{-8s+2}{10s^2+7s+1}$$

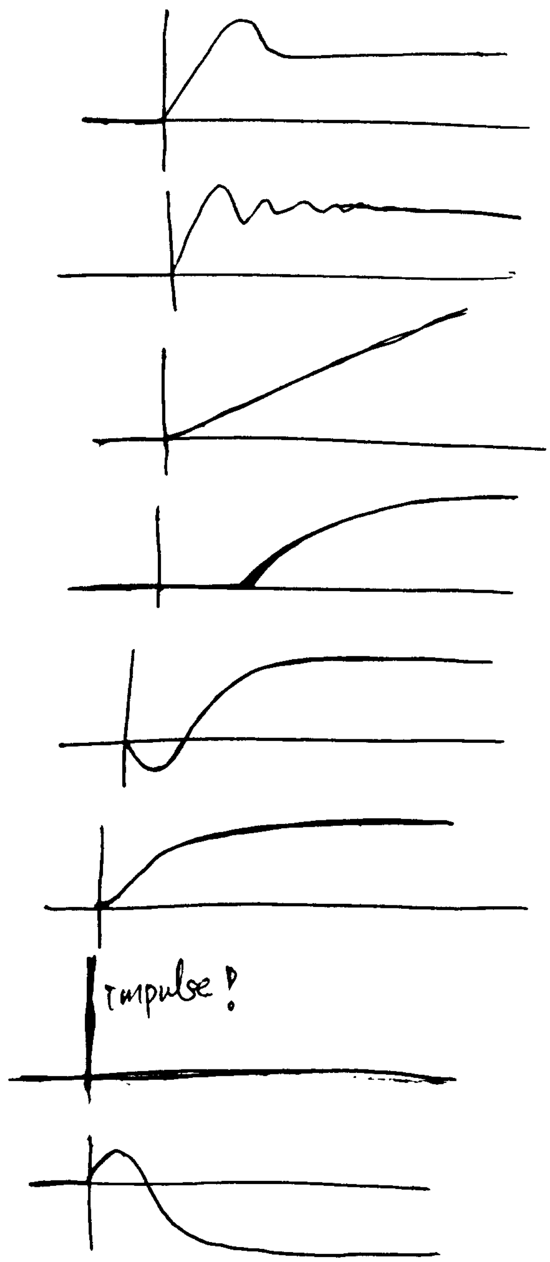
$$\frac{8s-2}{10s^2+7s+1}$$

$$\frac{5}{10s^2+2s+1}$$

$$\frac{2}{6s+1}e^{-5s}$$

$$\frac{2}{s}$$

$$s$$



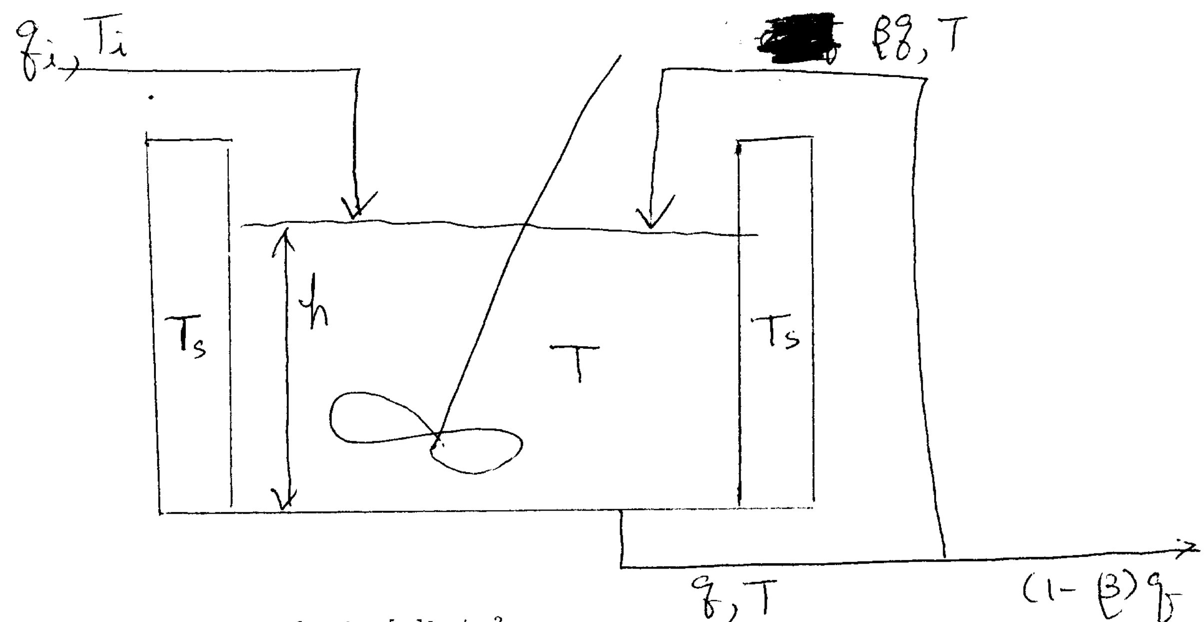
CHE 456 QUIZ #1

Instructor: Jay H. Lee

September 13, 1998

Closed-Book, 15 minutes

1. Shown below is a well-mixed tank with a steam jacket providing the heat.



ρ	:	density $[=] kg/m^3$
q, q_i	:	volumetric flowrates $[=] m^3/min$
C_p	:	specific heat capacity $[=] kcal/(oC, kg)$
β	:	fraction of the outlet stream recycled back to the reactor
Q	:	rate of heat addition from the steam jacket $[=] kcal/min$
A	:	cross-sectional area of the tank $[=] m^2$

Make the following assumptions:

- The content of the tank is well mixed.
- The volumetric flowrate q is set independently of the tank height (through some flow controller).
- The density and the specific heat capacity are independent of the temperature.
- The rate of heat addition from the steam jacket to the reactor can be expressed as $UA_s(T_s - T)$, where U is the overall heat transfer coefficient and A_s is the area of heat transfer. Hence, the thermal capacity of the tank wall is assumed to be negligible.

Derive differential equations for $h(t)$ and $T(t)$ in the standard form (i.e., the left-hand-side of the equation should be $\frac{dh}{dt}$ (or $\frac{dT}{dt}$).

CHE 456 QUIZ #2

Instructor: Jay H. Lee

September 20, 1999

Closed-Book, 15 minutes

Consider the following expression in the Laplace domain:

$$\frac{\hat{y}(s)}{\hat{u}(s)} = \frac{5}{s^2 + 3s + 2}$$

1. Express the above transfer function in time domain.
2. Calculate the response of output y *in time domain* when a step change of size 2 is made on the input u at $t = 0$.