KMU 417

PROCESS CONTROL AND DESIGN

Instructor: Dr. Selis Önel

Midterm Examination

Thursday, November 27, 2008

Please give brief answers to the following questions. Show units for calculations. All answers should be in English.

Question 1. (15 pts)

Circle the correct word in the following sentence or fill in the blank with one of the words given below:

Analog, Black-box model, Deterministic model, Discrete, Distributed parameter, Economics, Gray-box model, Hard constraint, Lumped parameter, ODE's, PDE's, Process Control, Quality, Safety, Soft constraint, State, Steady state, Stochastic model, Transient

a) Temperature, pressure, flow, and composition may deviate in a chemical process. _____ is about managing disturbances, for product _____, _____, and _____.
b) A _____ is developed by incorporating empirical data into the fundamental equations that explain a process.
c) A _____ is developed by fitting/constructing a mathematical relationship as a function of process variables which can explain empirical data or the data collected during process operation.
d) The fact that the composition of a product is desired to be between certain limits to sell this product, yet it is possible to violate the composition specifications without posing a safety or environmental hazard is a _____ on the system.
e) A minimum or maximum flow rate—a valve operates between the extremes of fully closed or fully open- is an example of _____ on a system.
f) Each device in a control loop must supply or receive a signal from another device. If these signals are continuous, such as electrical current or voltage, control is _____, if the signals are communicated at discrete intervals of time, control is _____.
g) In a _____ system, such as a perfectly well mixed vessel, dependent variable changes with time but does not change with spatial location and system equations result in initial-value _____
h) In a _____ system, dependent variable changes with time and spatial location within the process, therefore microscopic balances are typically applied yielding differential equations for conservation of mass, moles, or energy for a single point in the process and system equations result in _____
i) The _____ **o**f a dynamic system is the smallest set of variables such that the knowledge of these variables at $t = 0$, together with the knowledge of the input for $t \geq 0$, completely determines the behavior of the system for any time.

Question 2. (20 pts)

Assume a small fluid tank with an electric heater inserted. It is measured that a change in power (input) of 0.2 kW to this laboratory-scale heater may lead to a fluid temperature (output) change of 5 °C.

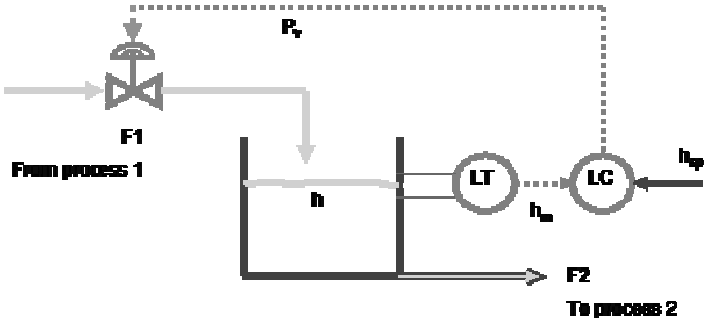
a) Is this is a positive gain process or a negative gain process?

b) Why?

c) Calculate the steady state process gain for this system?

d) If I wanted the steady state process gain to be 1 °C/kW, to get the same amount of change in fluid temperature should I use more or less powerful heater, i.e. larger scale heater or smaller scale heater?

Question 3. (10 pts)



The level-control problem has three critical pieces of instrumentation: Sensor, Actuator and Controller

_____ is the manipulated input device. In this problem, the manipulated input variable is _____

_____ measures the tank level and is represented with a _____in the figure

_____ changes the flow rate and is represented with a _____in the figure

_____ determines how much to vary the actuator, based on the sensor signal and is represented with a _____in the figure.

The valve used for this system is a _____valve that works with _____

Question 4. (20 pts)

A type I diabetic that cannot produce insulin must monitor his blood glucose by using blood glucose strips and provide insulin injections several times/day. It is also important to know the amount of glucose in the meals to determine the amount of insulin necessary to compensate for the glucose.

a. Discuss the actions taken by a type I diabetic in terms of the formulation of a **feedback/feedforward** control problem. State the objectives and list all variables.

Control objective(s).

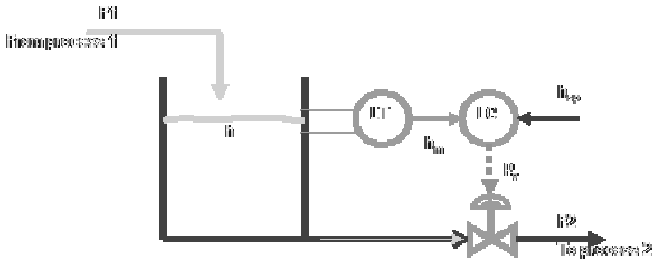
Input variables—classify these as manipulated or disturbance variables

Output variables—classify these as measured or unmeasured variables

Constraints—hard or soft.

b. Design an automated closed-loop system (use continuous blood glucose measurement and continuous insulin infusion pump). Draw a "process and instrumentation" diagram and the corresponding control block diagram.

Question 5. (30 pts)



Consider the level control problem shown

- Derive the process equations for this system assuming a cubic tank that expands and contracts in all directions with the level of the fluid in the tank and the outlet stream is a nonlinear function of the level of fluid in the tank given by $F2=Rh^{1/2}$, where R is the resistance of the valve to flow due to friction. (Hint: Volume of tank is given by $V=h^3$)
- Define the process time constant
- Define the steady state gain
- Derive the process transfer function
- Determine the time dependent response of h to a unit step disturbance and disturbance of magnitude M in the feed.
- Plot a simple graph of h with respect to t for both conditions.
- Check if your result is consistent with the initial conditions
- Check if your result is consistent with the final conditions