Georgia Tech
ChE 4400, Spring 2001
Midterm Exam 1, February 23, 2001
Closed Book, Closed Notes
60 minutes

1. Which of the following control mode is needed to eliminate offset?
   a. P-mode b. I-mode c. D-mode d. All of the above.
2. Which of the following control mode is responsible for "windup"?
   a. P-mode b. I-mode c. D-mode d. All of the above
3. Which of the following about feedback control is NOT true?
   a. It can stabilize an unstable system.
   b. It can destabilize a stable system.
   c. It can change overdamped dynamics into underdamped dynamics.
   d. It is particularly effective when the process has a large time delay or shows an inverse response.
4. Which of the following control strategy is effective for eliminating steam pressure line disturbances or (steam) valve errors in the temperature control of a jacketed reactor?
   a. Feedback control b. Feedforward control c. Combined feedback/feedforward control d. Cascade control
5. Which of the following is NOT true in sizing a valve?
   a. Smaller size implies increased pumping requirement.
   b. Smaller size means less controllability and more nonlinear behavior.
   c. Larger valve size causes less pressure drop for a given flowrate.
   d. Rule of thumb is that the pressure drop across the valve at a nominal flowrate should be about ¼ - 1/3 of the total pressure drop.
6. You are controlling a reactor temperature by a steam flow valve. The valve is Air-To-Open type. You should be using
   a. Direct-Acting Mode
   b. Indirect-Acting Mode
   c. Reverse-Acting Mode
   d. Straight-Acting Mode
7. Which of the following is true about Distributed Control System (DCS)?
   a. It's a single centralized computer system that performs control for the entire plant.
   b. It's a modularized controller that can handle only a single PID loop.
   c. Each unit can handle tens of analog and digital inputs and outputs and can be networked with other units and computers.
   d. It performs high-level functions such as process scheduling, optimization, and advanced control.
8. "Transfer function" is
   a. Laplace transform of a step response curve.
   b. Laplace transform of a differential equation with a general forcing term (input).
   c. Laplace transform of a differential equation with a particular forcing term.

d. Laplace transform of the time signal of the output.

9. Which of the following is NOT true about impulse?
    a. It is an ideal signal that has infinite height and infinitesimal width.
    b. It is used to approximate a pulse of a very short duration.
    c. It is measured by height, which should be set equal to the height of the pulse it is approximating.
    d. It can be used to approximate forcing functions like tracer injection or (very fast) pouring a beaker of liquid into a tank.
10. Which of the following is NOT true about linearization?
    a. It is an approximation that is valid around a particular equilibrium.
    b. Once linearized, the model can be converted to a transfer function form via Laplace transform.
    c. Linearization involves taking partial derivatives of nonlinear functions.
    d. It is an approximation that is globally valid and can be used to predict the output response far away from the reference equilibrium.

11. Match the following transfer functions with step responses.

a. $\frac{k}{s}$

b. $\frac{5}{5s+1}$

c. $\frac{5}{5s-1}$

d. $\frac{5}{s^2+s+1}$

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

f. $\frac{2s+1}{s^2+5s+4}$

g. $\dfrac{7s+1}{s^2+5s+4}$

h. $\dfrac{-2s+1}{s^2+5s+4}$

i. $\dfrac{e^{-2s}}{s^2+5s+4}$

j. $\dfrac{1}{(0.1s+1)^{100}}$

12. Consider an arrangement of a heat exchanger and a control valve in series. At nominal flowrate 220 gal/min, it was measured that the pressure drop across the heat exchanger to be 60psi.
    a. Calculate the pumping requirement in order to make the pressure drop across the control valve to be 1/4 of the total pressure drop at the nominal flowrate.
    b. Size an equal percentage valve (R=50) for the maximum flow rate of 250 gal/min.
    c. Write the equation for the installed characteristic curve and plot the curve. You can leave the equation in implicit form.
    d. Calculate the flowrate that results when the valve is half-open. Is it half of the maximum flowrate?

    Hint: The valve equation for equal percentage valve is

$$q = C_v R^{\ell-1}\sqrt{\frac{\Delta P_v}{g_s}}$$

13. A can of beer with the initial temperature of 90ºF (the room temperature) is put into a freezer of temperature –10 ºF at t=0. Calculate the transient response of the beer as a function of time. The entire beer (including the can) can be though of as having a uniform temperature at any given moment. The heat capacity of the beer is 1.5 Btu/lb ºF and weighs 0.8 lb. The heat transfer coefficient between the beer and the outside temperature is 2.0 Btu/hr ºF ft^3. The heat transfer surface area is 0.3 ft^3.