1. A system has the transfer function $G(s) = 4.5(s + 5)/(s + 4.5)(s^2 + 2s + 5)$. What are the time constants or undamped natural frequency and damping ratio, as appropriate, of the components of the transient response to a step input? Which component would you expect to dominate, and why? (20%)

2. Consider the unity feedback system with $G(s) = (s + 2)/(s - 2)$ and controller $D(s)$. Design the simplest controller $D(s)$ that will satisfy all of the following specifications:

   (a) The steady-state error for constant input must be zero.

   (b) The system settling time must be about 4 sec.

   (c) The system damping ratio should be 0.7.

   Derive the approximate controller parameter value. (20%)

3. Consider the system shown below. (a) Find the equations that must be satisfied by k_1, k_2, and k_3 to ensure both a steady-state value of no more than 0.1 for y in response to a unit step T_d and a system damping ratio 0.5. (b) Which of k_1 and k_2 must be adjustable to enable both specification in part (a) to be met? (20%)
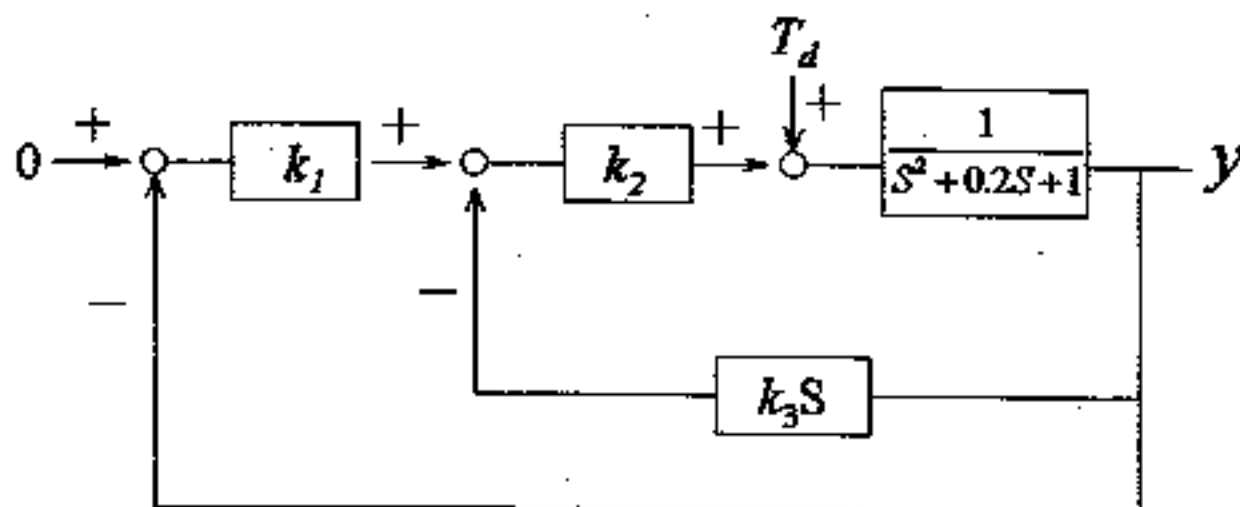
4. Consider a unity feedback system with loop gain $k(s + 5)/s(s + 2)(s + 3)$. If $k = 8$, the closed-loop poles are located at -4, $-0.5 \pm j3.12$. When the open-loop pole at -2 has a variations δ, discuss which direction of variation is dangerous. (20%)

5. Determine the steady-forced response of a system with transfer function $T(s) = 1/(2s + 1)(0.1s + 1)$ to the following sinusoidal inputs.

   (a) $r(t) = 2\sin 0.5t$

   (b) $r(t) = 2\sin 5t$ (20%)