1. In the system with rate feedback as shown below:
   (a) Sketch the loci and find $K$ for a system damping ratio 0.5 for the dominating poles. (10%)
   (b) Find the steady-state errors for step and ramp inputs for $K$ of part (a). (10%)

![System diagram](attachment:image.png)

2. For the system shown below with $G(s) = (s + 1)/[(s + 2)(s + 20)]$:
   (1) Find $K$ so that the dominant system time constant will be $T = 0.667$ sec, and for this $K$ also determine the second pole of the system. (10%)
   (2) Calculate the unit step response for $K$ of part (a). (5%)

![System diagram](attachment:image.png)

3. Determine the output transform $Y(s)$ for the differential equation

$$\frac{d^3y}{dt^3} + 3 \frac{d^2y}{dt^2} - \frac{dy}{dt} + 6y = \frac{d^2u}{dt^2} - u$$

where $Y(s)$ is the Laplace transform of $y(t)$, $y(t)$ = output, $u(t)$ = input = $5 \sin t$, and initial conditions are

$$y(0^*) = \frac{dy}{dt}_{t=0^*} = 0, \quad \frac{d^2y}{dt^2}_{t=0^*} = 1.$$
4. Consider the unity feedback system with

\[ G(s) = \frac{K}{s(s+5)(s+15)} \]

(1) Find the location of the dominant poles for the system to operate with a 2.21-seconds settling time and an overshoot of 20%. (Use a 2% settling time) (5%)

(2) Design a PD controller to reduce the settling time by a factor of 4 while continuing to operate the system with 20% overshoot. (10%)

5. Given the system shown below, find the following:

(1) The closed-loop transfer function and the system type. (8%)

(2) The steady-state errors for a step input of \(5u(t)\) and a ramp input of \(5tu(t)\). (7%)

(3) Discuss the validity of your answers to part (b). (5%)
6. Given the unity feedback system with

\[ G(s) = \frac{K(s + 1)}{s(s + 2)(s + 3)(s + 4)} \]

do the following:

(1) Find the asymptotes, jω-axis crossing and the range of K for stability. Also sketch the root locus. (10%)

(2) Find the value of K for which the closed-loop transfer function will have a pole on the real axis at -0.5. (5%)