Midterm Exam (October 28, 2004) for

ME 431 – Control Systems I and ME 862 – Analysis & Synthesis of Linear Control Systems

Instructor: Dr. Daniel CHEN

Time: 2 hours

Instructions:

1. Answer ALL questions

2. Calculator are allowed

3. Students may bring one page (both sides) of letter-size notes

4. Question sheets are to be returned with examination booklets

1. [Marks: 36] A translational mechanical system is shown schematically in Figure 1. Given that $M = 1\,\text{kg}$, $f_v = 3\,\text{N}-\text{s/m}$, and $K = 4\,\text{N/m}$, do the following:

   a) Find the transfer function $G(s) = X(s)/F(s)$.

   b) Find the system poles and then represent them in the complex plane.

   c) Is this system stable or not? Why?

   d) Find ζ (damping ratio) and ω_n (natural frequency).

   e) Evaluate $\%OS$ (percent overshoot), T_s (settling time), and T_p (peak time) for the step response.

   f) Find the analytical expressions for the magnitude and phase response.

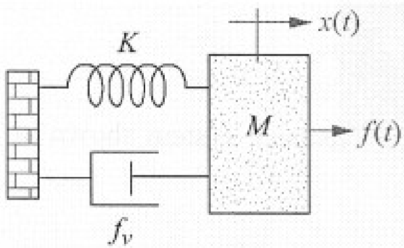

Figure 1

2. [Marks: 6] Reduce the block diagram shown in Figure 2 to a single transfer function, $T(s)=C(s)/R(s)$.

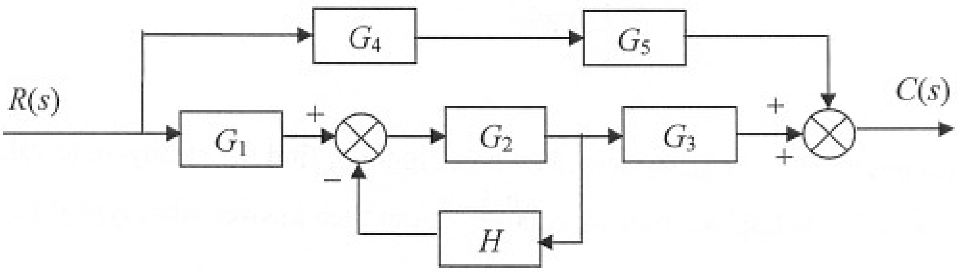

Figure 2

3. [Marks: 24] Sketch the Bode magnitude and phase plots for the following transfer functions.

a) $G(s) = \dfrac{10s}{(s+1)}$

b) $G(s) = \dfrac{s+100}{10s(s+10)}$

4. [Marks: 16] Determine the stability for the systems with closed-loop transfer functions of

a) $T(s) = \dfrac{1}{s^5 + 6s^4 + 5s^3 + 8s^2 + s + 6}$

b) $T(s) = \dfrac{10}{s^4 + s^3 + 8s^2 + 5s + 15}$

5. [Marks: 8] Find the range of gain, K, for the unity feedback system shown in Figure 3 such that the system is stable.

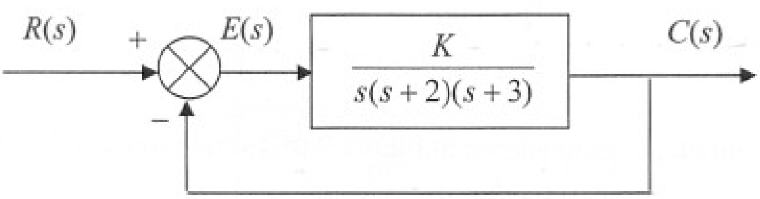

Figure 3

6. [Marks: 10] Suppose K =12 in the system shown in Figure 3, find the steady-state value if the input is t (i.e., a ramp, its Laplace transform is $\frac{1}{s^2}$). And then answer what type (i.e., Type 0, or 1, 2, ...) this system is and explain why.

The End