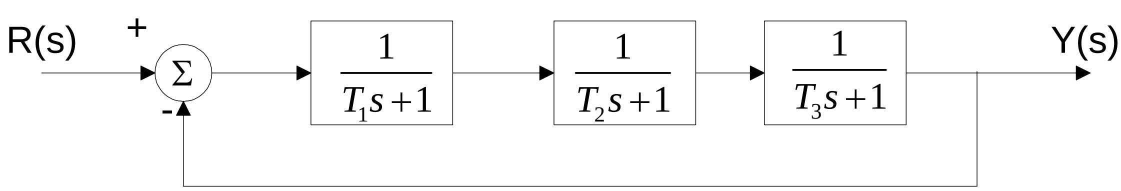
Department of Electrical and Computer Engineering
University of Massachusetts Amherst

ECE580, Fall 2004
Midterm Exam

This is a closed book exam.
Explain answers *fully*.
This is a two hour exam. Total score is 100 points.
Please sign the ECE Honor Code Page and submit it with your completed exam.

Problem 1 (15 points)

We have the following system:



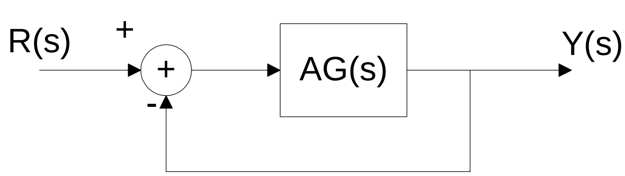
This closed-loop system is

(1) Definitely stable since every block is a first-order system;
(2) Not stable since this is a closed-loop system;
(3) Definitely stable since all the coefficients in the characteristic polynomial are positive;
(4) None of the above.

Choose the right answer (only one) and explain it.

Problem 2 (15 points)

Define $G(s)=\dfrac{\frac{1}{K}}{\left(\frac{s}{\omega_n}\right)^2+2\varsigma\left(\frac{s}{\omega_n}\right)+1}$ and consider the control system shown below. Take $0<\varsigma<1$.

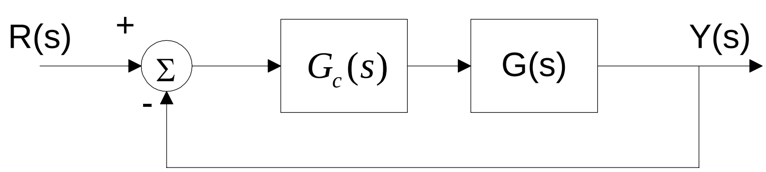


(1) Does changing the constant factor A change the frequency of oscillation of the output y(t) when the input r(t) is a unit impulse? Explain.
(2) Does changing the constant factor A change the time required for the oscillatory impulse response to decay away? Why?

Hint: Calculate the inverse Laplace transform of $\frac{\omega_n^2}{s^2 + 2\varsigma\omega_n s + \omega_n^2}$

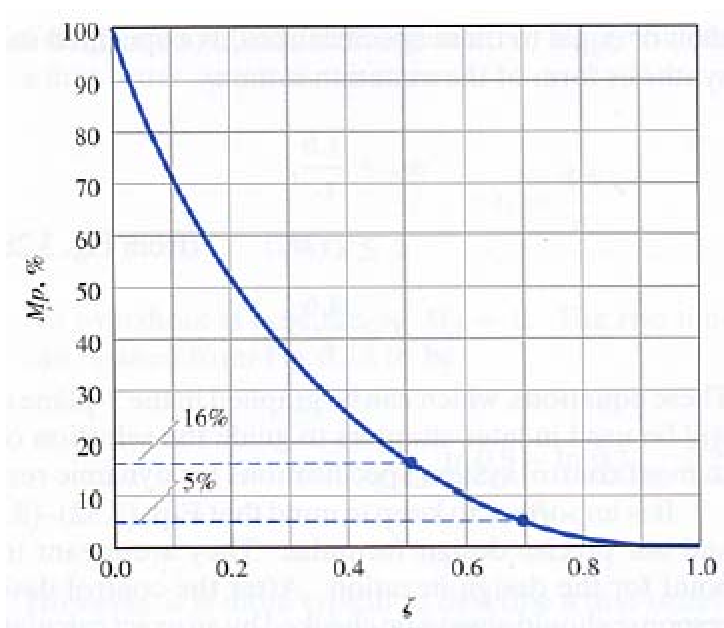
Problem 3 (20 points)

Consider the system shown in the following figure.



Let $G(s) = \frac{1}{s(s+3)}$, $G_c(s) = \frac{Ks}{s+p}$

Find K, p such that the closed loop system has a 5% overshoot to a step input and a settling time of $\frac{3}{4}$ s (5% criterion). Note that the settling time for 5% criterion is $\frac{3}{\sigma}$ (where σ is the real part of the closed loop poles). You need to check the following figure for the overshoot-damping ratio relation.



Overshoot M_p versus damping ratio ς
for the second-order system

Problem 4 (15 points)

Use Routh-Hurwitz criterion to proof that if $abc - c^2 - a^2 d > 0$ where a, b, c and d are positive real numbers then the system

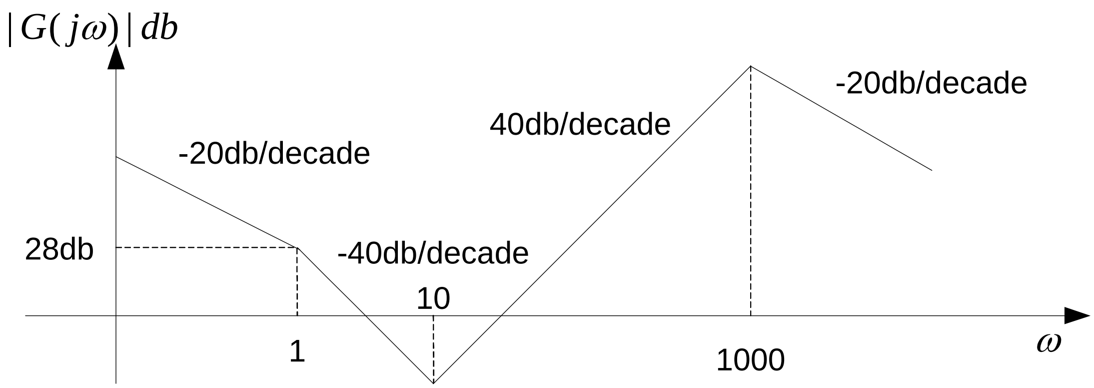
$$\frac{as+b}{s^4 + as^3 + bs^2 + cs + d}$$

is stable.

Problem 5 (20 points)

Consider the following open-loop frequency response. Assume that the open-loop system is a minimum phase system with gain constant K as

$$\frac{K(T_a s+1)(T_b s+1)\ldots}{s^n (T_1 s+1)(T_2 s+1)\ldots}$$



(a) Determine the transfer function of the open-loop system;
(b) Determine the system type and error constant (For unity-feedback control system)

Hint: the first segment of the asymptotes is $\dfrac{K}{j\omega}$

Problem 6 (15 points)

Consider an unity-feedback control system with the open-loop transfer function

$$G(s) = \frac{2as + a^2}{s^2}$$

For a unit-step input, consider the following performance indices:

$$J_1 = \int_0^\infty e^2(t)dt$$

$$J_2 = \int_0^\infty te^2(t)dt$$

where e(t) is the system error. Use the final value theorem to calculate the values of J_1 and J_2.

Hint: Note that

$$\int_0^\infty f(t)dt = \lim_{t\to\infty}\int_0^t f(t)dt = \lim_{s\to 0} s\frac{F(s)}{s} \quad \text{(F(s)=L[f(t)])}$$

when all poles of $\frac{F(s)}{s}$ are in the left half of the s-plane.

Department of Electrical and Computer Engineering
University of Massachusetts Amherst

ECE580
Midterm Exam

November 4, 2004

____

NAME

ECE Honor Code

On my honor, I have not given or received aid on this exam

____

SIGNATURE