ME 431/AE411 Control Systems I
Midterm
October 2001

Time: 2 hours
Instructor: S. Habibi
Instructions: 1- Answer all 4 questions
2- Calculators are allowed
3- Students may bring up to 1 page of letter-size notes

(22) Q1: An electromechanical system is shown in Figure 1:

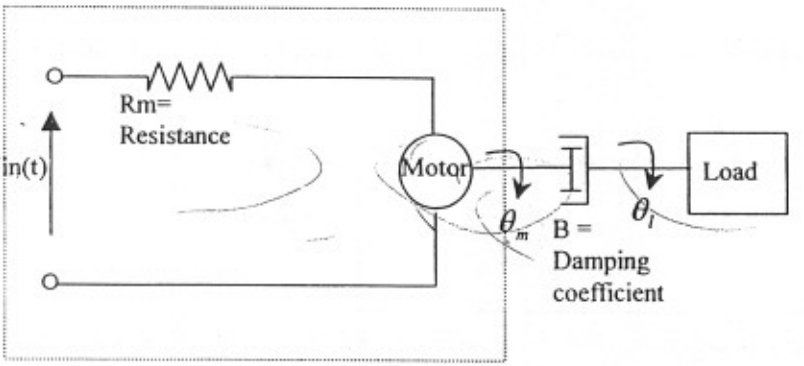

Figure 1

Constant Field DC Motor With
θ_m =motor angular position
θ_l =load angular position
Kt=motor torque constant
Ke= constant relating back emf to motor angular velocity.
Tm= motor torque
I= Current
(some formulas:
Tm=Kt * I;
Back emf= Ke * angular velocity)
Jm=Motor inertia
Jl=Load Inertia

a) Write the differential equations of the electromechanical system in Figure 1 and find their Laplace transform.

b) Assuming that the input is *Vin* and the output is θ_l, draw a block diagram representation of the system in Figure 1.

(20) Q2:

a) Use block diagram reduction to obtain the transfer function $\frac{C(s)}{R(s)}$ of the system represented by the block diagram in Figure 2.

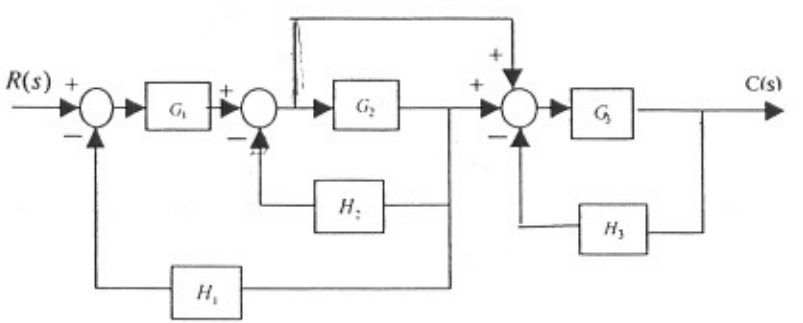

Figure 2

(20) Q3: Given a unit step input, sketch the time response of the following system:

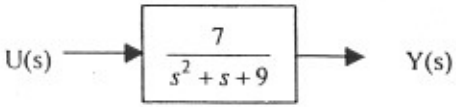

Figure 3

show the value of:

- output at steady state,
- output at maximum overshoot,
- peak time, and
- settling time.

(38) Q4: Proportional control with gain K_p is used for the control of the open loop system of Figure 3, as shown in Figure 4.

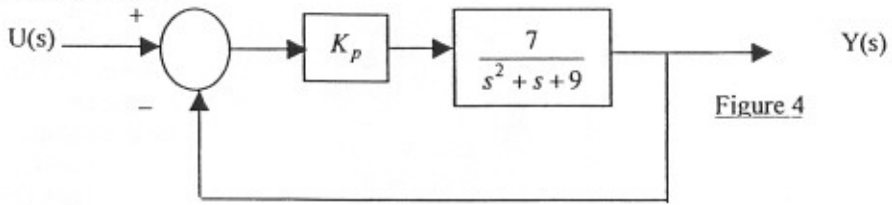

Figure 4

a) Explain, without doing any calculations, what would happen to the response of your system if the gain K_p is increased. faster, less S.S. error, larger overshoot

b) For the closed loop system of Figure 4 with $K_p = 10$, calculate the following:

- the transfer function;
- the natural frequency;
- the damping ratio; and
- the steady state output of the system given a unit step input.

c) Use rate feedback to obtain critical damping for the system of Figure 4. Your answer should include a numerical value for the gain associated with the rate feedback.