O K L A H O M A   S T A T E   U N I V E R S I T Y

S C H O O L  O F  E L E C T R I C A L  A N D  C O M P U T E R  E N G I N E E R I N G
S C H O O L  O F  M E C H A N I C A L  A N D  A E R O S P A C E  E N G I N E E R I N G

# ECEN 4413/MAE 4053
# Automatic Control Systems
# Spring 2011

## Midterm Exam #2

**DO ALL FOUR**

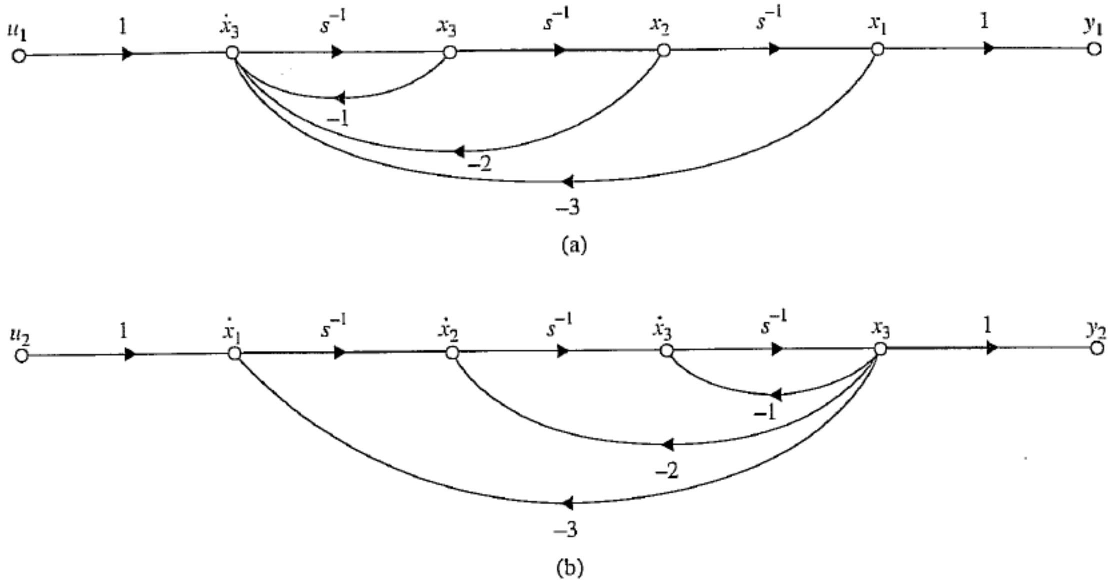
**Name : ______________________________**

**E-Mail Address:_______________________________________**

**Problem 1**:

a) Show that the input-output transfer functions of the two systems in the state diagrams given below (without showing the initial conditions) are the same.

b) Derive the state space representations for both state diagram as $\dot{x}(t) = Ax(t) + Br(t), \quad y(t) = Cx(t)$,



**Problem 2**:

The equations that describe the dynamics of a motor control system are

$$e_a(t) = R_a i_a(t) + L_a \frac{di_a(t)}{dt} + K_b \frac{d\theta_m(t)}{dt}$$

$$T_m(t) = K_i i_a(t)$$

$$T_m(t) = J \frac{d^2\theta_m(t)}{dt^2} + B \frac{d\theta_m(t)}{dt} + K\theta_m(t)$$

$$e_a(t) = K_a e(t)$$

$$e(t) = K_s\left[\theta_r(t) - \theta_m(t)\right]$$

a) Assign the state variables as $x_1(t) = \theta_m(t)$, $x_2(t) = d\theta_m(t)/dt$, and $x_3(t) = i_a(t)$. Express the state space representation in the form of

$$\frac{dx(t)}{dt} = Ax(t) + B\theta_r(t), \quad \theta_m(t) = Cx(t).$$

b) Develop a corresponding state diagram.

**Problem 3**:

The loop transfer function of a single-loop feedback control system is given as

$$G(s)H(s) = \frac{K(s+5)}{s(s+2)(1+Ts)}.$$

The parameters *K* and *T* may be represented in a plane with *K* as the horizontal axis and *T* as the vertical axis. Determine the regions in the *T*-versus-*K* parameter plane where the closed-loop system is asymptotically stable and where it is unstable. Indicate the boundary on which the system is marginally stable.

**Problem 4**:

Find the range of $K$ in $G(s) = \dfrac{K}{s^4 + 6s^3 + 13s^2 + 12s + 4}$ for which the $G$-configuration equivalent system shown below is stable.