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

ECEN 4413
Automatic Control Systems
Spring 2009

Midterm Exam #2

Choose any four out of five problems.
Please specify which four listed below to be graded :
1)_____; 2)_____; 3)_____; 4)_____;

Name : _____

E-Mail Address:_____

Problem 1:

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

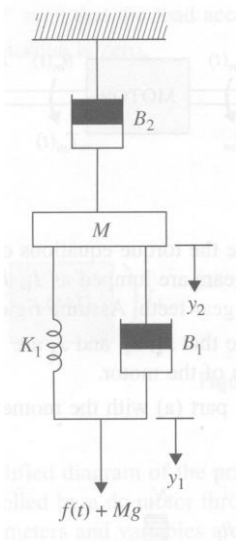
$$\frac{dx(t)}{dt} = Ax(t) + B\theta_r(t), \quad \theta_m(t) = Cx(t).$$

b) Develop a corresponding state diagram.

c) Find the transfer function $G(s) = \Theta_m(s)/E(s)$ when the feedback path from $\Theta_m(s)$ to $E(s)$ is broken. Find the closed-loop transfer function, $M(s) = \Theta_m(s)/\Theta_r(s)$.

Problem 2:

Write the equation of motion for the linear translational system shown below. Draw the state diagram using a minimum number of integrators. Write the state equation from the state diagram. Find the transfer functions $Y_1(s)/F(s)$ and $Y_2(s)/F(s)$. Set $Mg = 0$ for the transfer function.



Problem 3:

For the system described by input-output differential equation given below,

$$c\dddot{y} = (a+1)y + \dot{y} - b\ddot{y} + 2u + \dot{u} + \ddot{u},$$

find the state space representation in the form of

$$\dot{x}(t) = Ax(t) + bu(t)$$
$$y(t) = cx(t) + du(t)$$,

where input is $u(t)$ and output is $y(t)$.

Problem 4:

For the state variable description,

$$\dot{x}(t) = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix} x(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t),$$

$$y(t) = \begin{bmatrix} 0 & 1 \end{bmatrix} x(t)$$

if $u(t) = e^{-3t} u_s(t)$, where $u_s(t)$ is the unit step function and initial conditions are all zeros, find $y(t)$.

Problem 5:

Derive the state space representation of the system in the state diagram shown below

$\dot{x}(t) = Ax(t) + Br(t), \quad y(t) = Cx(t)$.

Please note the initial conditions are ignored here.