

OKLAHOMA STATE UNIVERSITY  
SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING



**ECEN 5713 Linear Systems**  
**Spring 2000**  
**Midterm Exam #1**



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**Problem 1:**

As defined in the first problem of Homework Assignment #1,

$$T_{\tau}(u(t)) = \begin{cases} u(t) & t \leq \tau \\ 0, & t > \tau \end{cases},$$

and

$$Q_{\tau}(u(t)) = u(t - \tau),$$

respectively. If a given system is described by

$$y(t) = T_{\tau}(Q_{\tau}(u(t))),$$

Is it causal ? Is it linear ? And is it time-invariant (fixed) ? Justify your answers.

**Problem 2:**

Find the *observable* canonical form realization (in minimal order) for a SISO continuous-time system given below

$$5t^2 \ddot{y}(t) + (t-1)\dot{y}(t) + e^{-2t} y(t) = 2\ddot{u}(t) + 2t\dot{u}(t) - t^2 u(t).$$

Notice that gain blocks may be *time* dependent. Show the state space representation and its corresponding simulation diagram.

**Problem 3:**

Realize the following SIMO discrete-time, time-varying system and show one possible state space representation, i.e.,  $\{A(k), B(k), C(k), D(k)\}$ ,

$$y_1(k+2) + 2y_2(k+2) + k^2 y_1(k) = u(k+2) + e^k u(k)$$

$$y_2(k+1) + ky_1(k) = ku(k)$$

**Problem 4:**

Given two discrete-time, time-varying SISO systems described by

$$y(k) + k^2 y(k-1) + ky(k-2) = u(k) + k^2 u(k-1) + ku(k-2), \quad (1)$$

and

$$y(k+2) + (k+1)^2 y(k+1) + (k+2)y(k) = u(k+2) + (k+1)^2 u(k+1) + (k+2)u(k). \quad (2)$$

Please derive their observable canonical forms and the corresponding state space representations (i.e.,  $\{A_1(k), B_1(k), C_1(k), D_1(k)\}$  and  $\{A_2(k), B_2(k), C_2(k), D_2(k)\}$ ). Are they the same, if not, why? please comment.