OKLAHOMA STATE UNIVERSITY

SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING

ECEN 5713 Linear System
Spring 1998
Midterm Exam #1

Name : ______________________________

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<u>Problem 1</u>:
A system has zero-state response

$$y(t) = f\{u(t)\} = \int_{-\infty}^{\infty} (\tau - t)^3 u(\tau) 1(t - \tau - 1) d\tau$$

where the unit-step function $1(\lambda)$ is defined by

$$1(\lambda - a) = \begin{cases} 0, & \text{for } \lambda < a \\ 1, & \text{for } \lambda \geq \text{a} \end{cases}.$$

Determine whether this system is or is not a) causal, b) time-varying, c) zero-memory and d) zero-state linear. Please justify your answer.

Problem 2:
Linearize the bilinear control system

$$\ddot{y}(t) + \left(3 + \dot{y}^2(t)\right)\dot{y}(t) + \left(1 + y(t) + y^2(t)\right)u(t) = 0$$

about the equilibrium solution ($y = 0,\ \dot{y} = 0$) when input $u(t) = 0$. Show the linearized state space representation.

Problem 3:
Consider the proper rational transfer function with complex conjugate poles, as, e.g., in the transfer function $H(s) = \frac{as+b}{(s+c)^2+d^2}$, then $H(s)$ can be written as

$$H(s) = \frac{a/(s+c)}{1+\left(d^2/(s+c)^2\right)} + \frac{(b-ac)/(s+c)^2}{1+\left(d^2/(s+c)^2\right)}$$

and can be realized as indicated in the block diagram shown on the left. $\frac{1}{q-\lambda_i}$ and $q = d/dt$ denotes the integrator building block shown on the right.

Problem 4:

Find the observable canonical form realization (in minimal order) for discrete-time system

$$\ddot{y}(t) + 2e^{-2t}\dot{y}(t) + 3\cos t\, y(t) = t\ddot{u}(t) + e^{-t}\dot{u}(t) - u(t)$$

Notice that gain blocks may be time-varying.