**Problem 1:**
A system has zero-state response

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

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

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

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
\[ \ddot{y}(t) + (3 + \dot{y}^2(t)) \dot{y}(t) + (1 + y(t) + y^2(t))u(t) = 0 \]
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

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

and can be realized as indicated in the block diagram shown on the left. \( \frac{1}{q - \lambda_i} \) and \( q = \frac{d}{dt} \) 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.