

1. (15%) Please show three types of nonlinear elements and plot their input-output relationships.
2. (30%) Explain the following definitions: (3 points each)

- (a) Relative stability
- (b) Gain-crossover frequency
- (c) Impulse response
- (d) Linear system
- (e) Causal system
- (f) Time-invariant system
- (g) Dead zone
- (h) State transition matrix
- (i) Transfer function
- (j) Steady state error

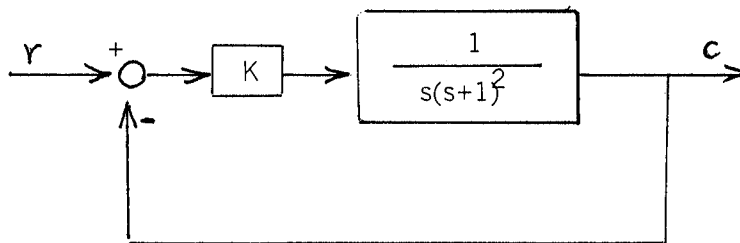
3. (25%) Consider the linear time-invariant system

$$\begin{aligned}\dot{x} &= Ax + Bu \\ y &= Cx\end{aligned}$$

Please answer the following questions. (5 points each)

- (a) How to check the stability of the system.
- (b) How to get the transfer function.
- (c) How to check the controllability of the system.
- (d) How to check the observability of the system
- (e) Why the observability may change through state feedback

4. (30%) Consider the control system



- (a) Find the range of the gain K for stability of the closed-loop control system. (6 points)
- (b) If $K=2$, what is the frequency (rad/sec) of oscillation for transients? (6 points)
- (c) If $K=1$, find the steady-state error (i.e. input minus output) when the input r is a unit step function. Does this unit step response exhibit an overshoot of the steady-state output? (6 points)
- (d) If $K=1$, find the steady-state error for a unit ramp input. (6 points)
- (e) If $K=1$ and $r(t) = 4 \cos 3t$, what is the steady-state response $c_{ss}(t)$? (6 points)