

Time domain Analysis

Outline

- **Introduction**
- **Test Input Signals**
- **Performance of a second-order system**
- **Effects of a Third Pole and a Zero on the Second-Order System Response**
- **Estimation of the Damping Ratio**
- **The s-plane Root Location and the Transient Response**

Test Input Signal

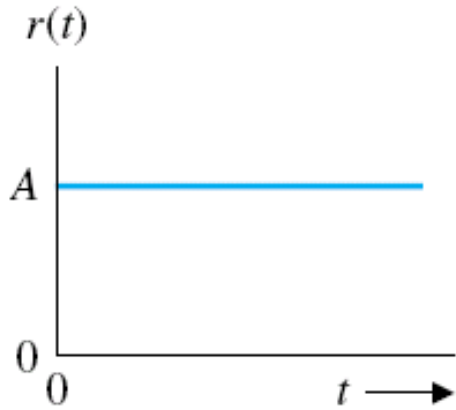
- **Since the actual input signal of the system is usually unknown, a standard test input signal is normally chosen. Commonly used test signals include step input, ramp input, and the parabolic input.**

General form of the standard test signals

$$r(t) = t^n$$

$$R(s) = n!/s^{n+1}$$

Test signals $r(t) = A t^n$

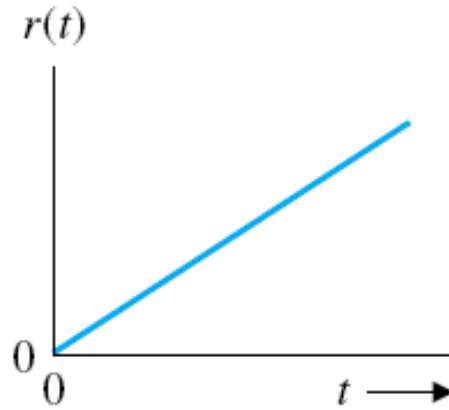


(a)

$$n = 0$$

$$r(t) = A$$

$$R(s) = A/s$$

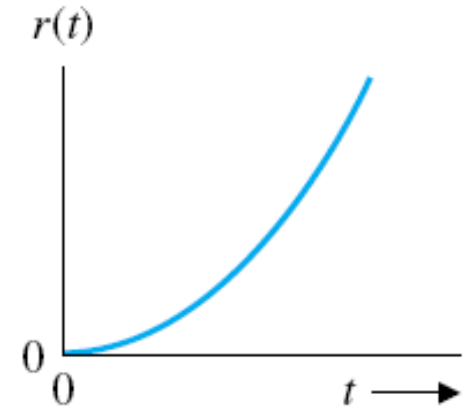


(b)

$$n = 1$$

$$r(t) = At$$

$$R(s) = A/s^2$$



(c)

$$n = 2$$

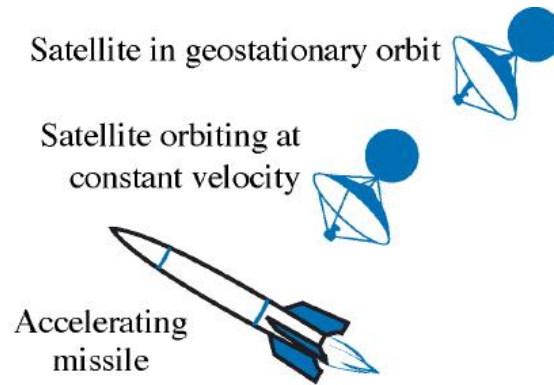
$$r(t) = At^2$$

$$R(s) = 2A/s^3$$

Table 5.1 Test Signal Inputs

Test Signal	$r(t)$	$R(s)$
Step <i>position</i>	$r(t) = A, t > 0$ $= 0, t < 0$	$R(s) = A/s$
Ramp <i>velocity</i>	$r(t) = At, t > 0$ $= 0, t < 0$	$R(s) = A/s^2$
Parabolic <i>acceleration</i>	$r(t) = At^2, t > 0$ $= 0, t < 0$	$R(s) = 2A/s^3$

Test inputs vary with target type



step

ramp

parabola

Tracking system



Steady-state error

- Is a difference between input and the output for a prescribed test input as

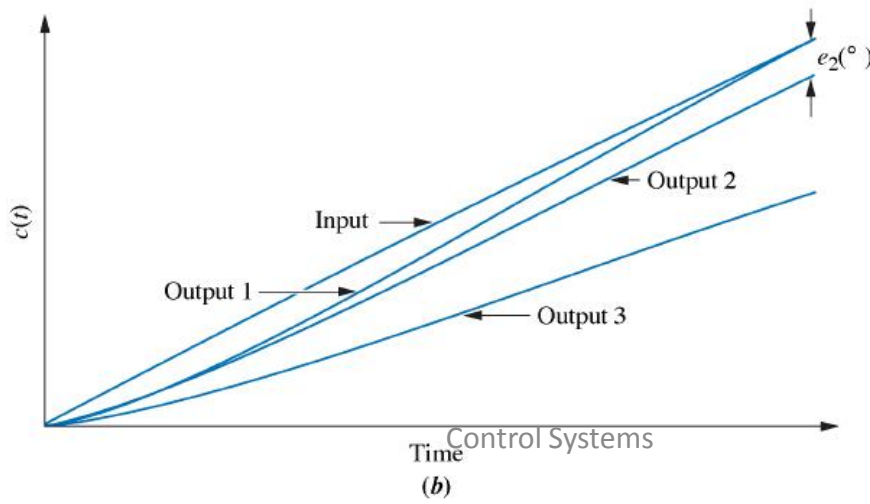
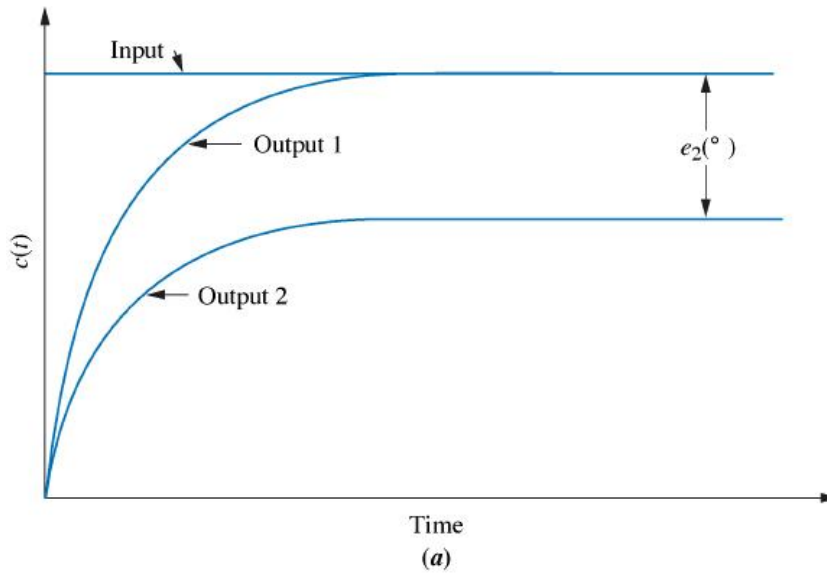
$$t \longrightarrow \infty$$

Application to stable systems

- **Unstable systems represent loss of control in the steady state and are not acceptable for use at all.**

Steady-state error:

a) step input, b) ramp input



Time response of systems

$$c(t) = c_t(t) + c_{ss}(t)$$

The time response of a control system is divided into two parts:

- $c_t(t)$ - transient response
- $c_{ss}(t)$ - steady state response

Transient response

- **All real control systems exhibit transient phenomena to some extent before steady state is reached.**

$$\lim c_t(t) = 0 \quad \text{for } t \rightarrow \infty$$

Steady-state response

- **The response that exists for a long time following any input signal initiation.**