Control Systems

Lecture: 1

Time domain Analysis

Topics Covered

- 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

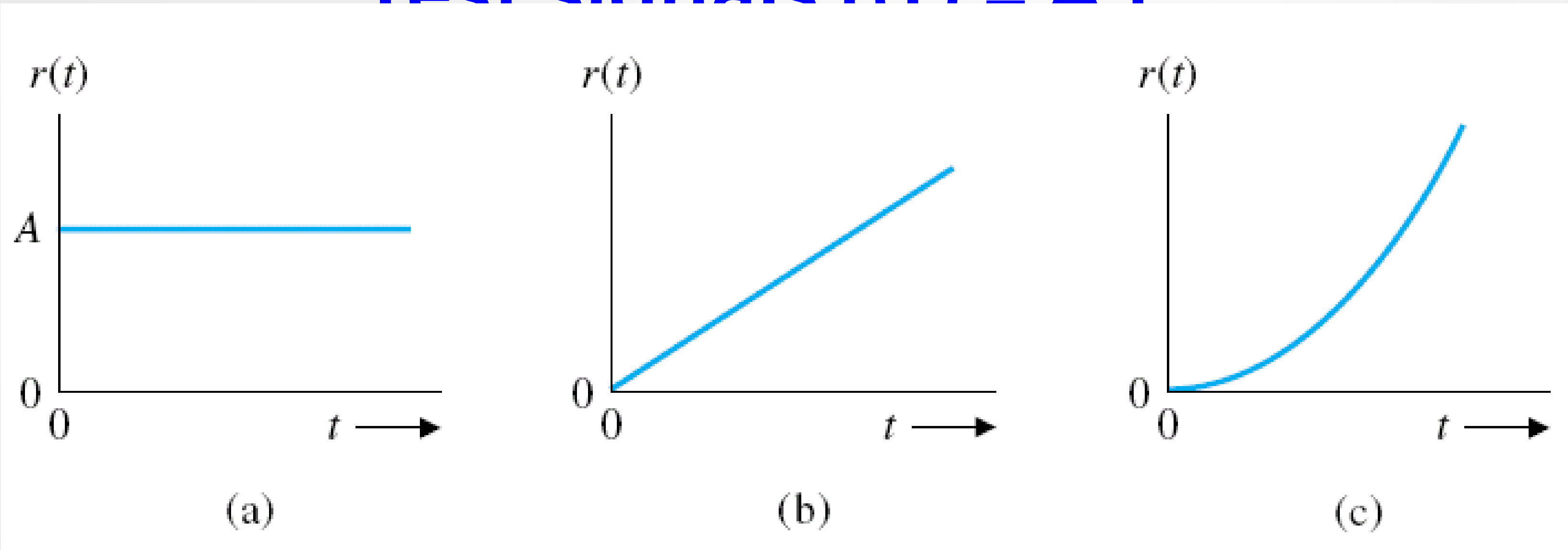
- **Since the actual input signal of the system is usually unknown, a standard test input signal is normally chosen. Commonly used test signals include step input, ramp input, and the parabolic input.**

General form of the standard test signals

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

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

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



n = 0

$r(t) = A$

$R(s) = A/s$

n = 1

$r(t) = At$

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

n = 2

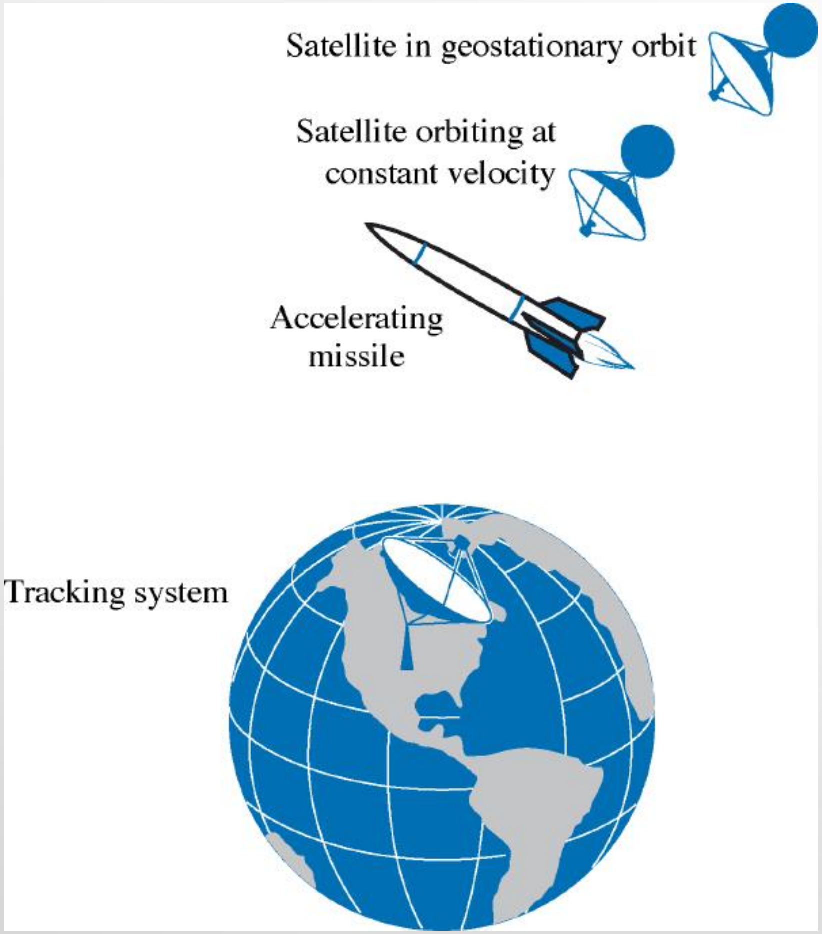
$r(t) = At^2$

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

Table 5.1 Test Signal Inputs

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

Test inputs vary with target type



step

ramp

parabola

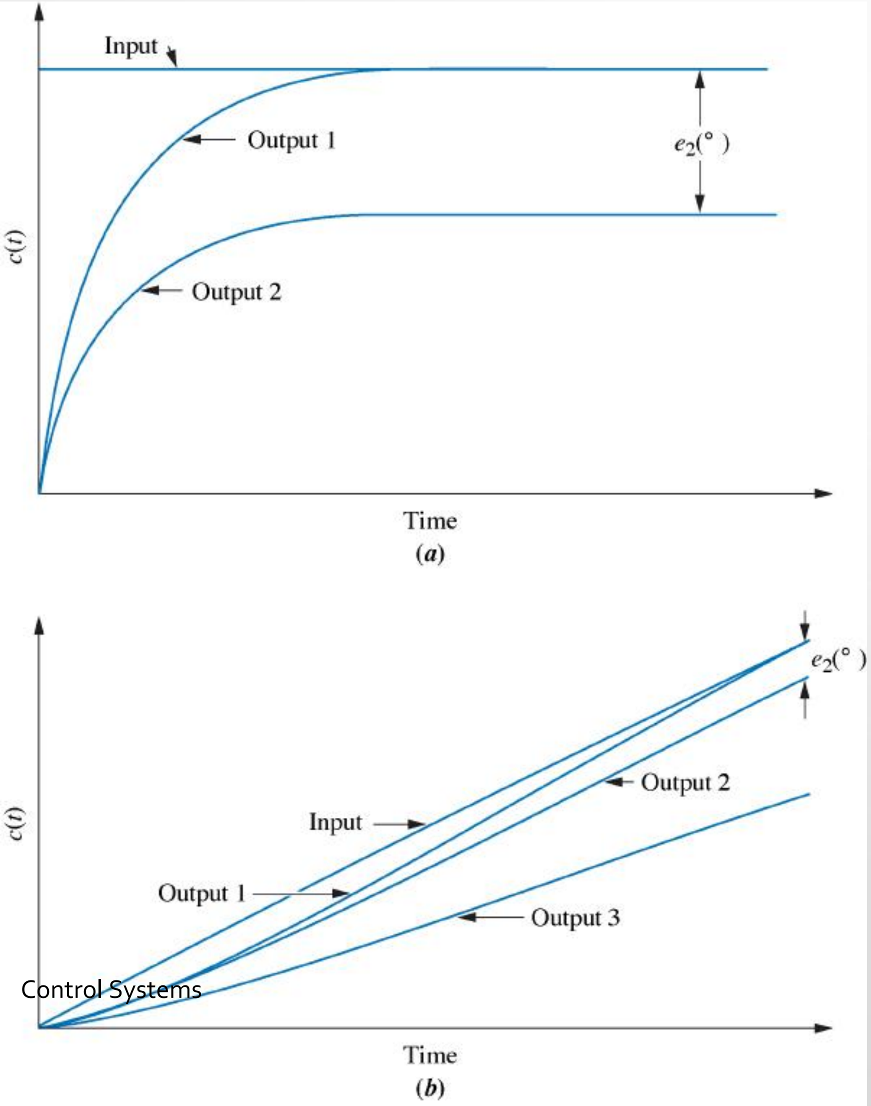
Steady-state error

- **Is a difference between input and the output for a prescribed test input as** $t \rightarrow \infty$

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 extend before steady state is reached.**

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

Steady-state response

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