ME451: Control Systems

Lecture 12
Time-domain specifications

Dr. Jongeun Choi
Department of Mechanical Engineering
Michigan State University

Course roadmap

Modeling

- ✓ Laplace transform
- ✓ Transfer function
- ✓ Models for systems
  - ✓ electrical
  - ✓ mechanical
  - ✓ electromechanical
- ✓ Block diagrams
- ✓ Linearization

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Analysis

- ► Time response
  - Transient
  - Steady state
- Frequency response
  - Bode plot
- ✓ Stability
  - ✓ Routh-Hurwitz
  - Nyquist

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Design

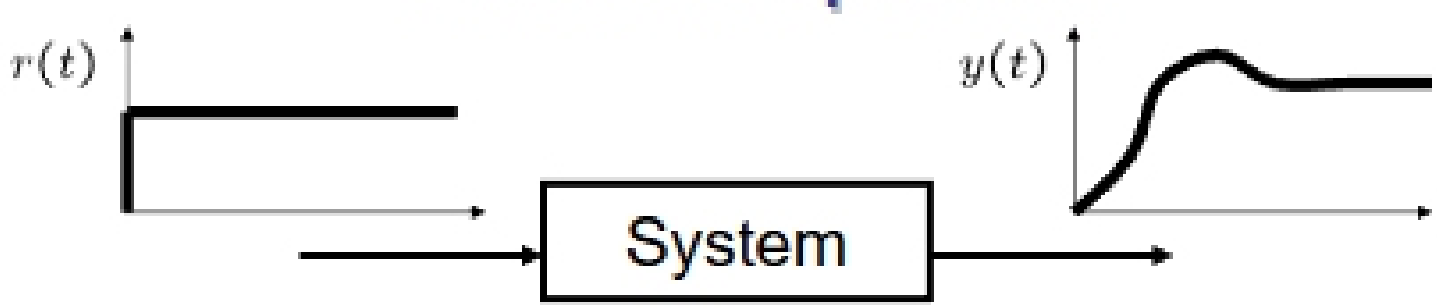
- Design specs
- Root locus
- Frequency domain
- PID & Lead-lag
- Design examples

(Matlab simulations &) laboratories

What we did and what we do next

- We have learned stability.
  - Definition in time domain
  - Condition in s-domain
  - Routh-Hurwitz criterion to check the condition
- Stability is a necessary requirement, but not sufficient in most control problems.
- Specifications other than stability
  - How to evaluate a system quantitatively in time domain?
  - How to give specifications in time domain?
  - What are the corresponding conditions in s-domain?

Time response



- We would like to analyze a system property by applying a *test input* r(t) and observing a time response y(t).
- Time response is divided as

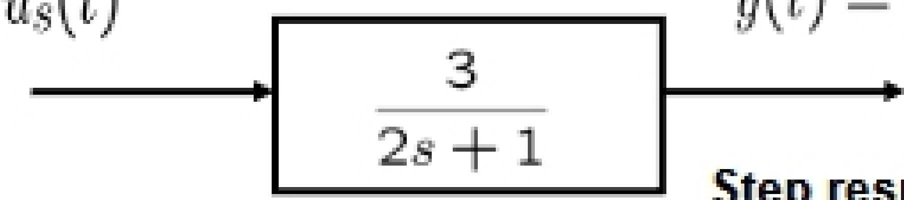
$$y(t) = y_t(t) + y_{ss}(t)$$

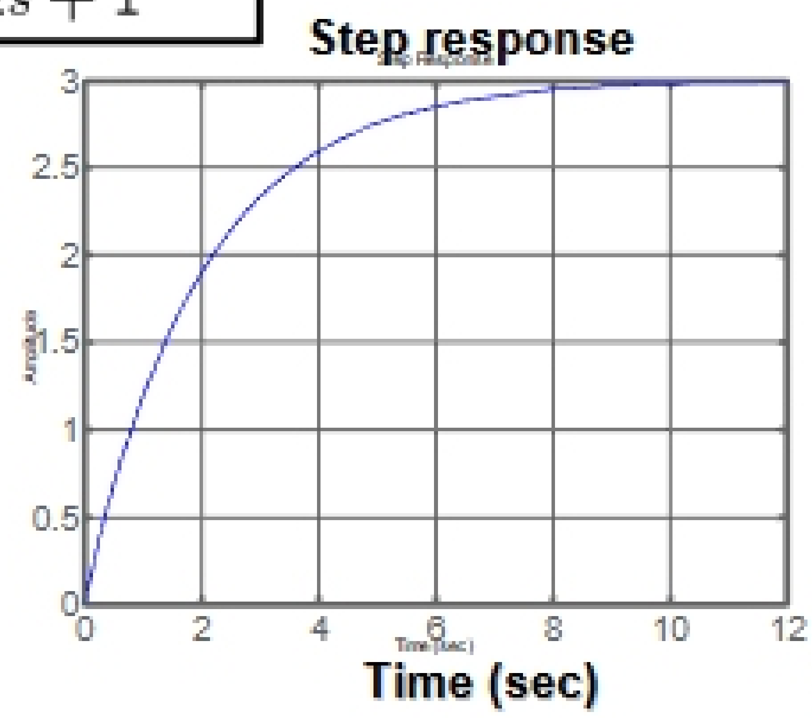
Transient response $\lim_{t\to\infty} y_t(t) = 0$

Steady-state response (after y_t dies out)

Example of transient & steady-state responses

$$r(t) = u_s(t) \qquad y(t) = 3 - 3e^{-\frac{t}{2}}$$





- Transient response
  $$y_t(t) = -3e^{-\frac{t}{2}}$$
- Steady-state resp.
  $$y_{ss}(t) = 3$$

Usage of time responses

- Modeling
  - Some parameters in the system may be estimated by time responses.
- Analysis
  - Evaluate transient and steady-state responses (Satisfactory or not?)
- Design
  - Given design specs in terms of transient and steady-state responses, design controllers satisfying all the design specs.