Lynbrook Robotics Team, FIRST 846

Control System Miniseries

05/15/2012

Lecture 1

- What is control system
- Control system diagram and terminology
- Mathematic relations.

What Is Control System

- A **control system** is a device, or set of devices to manage, command, direct or regulate the behavior of other devices or system. – From Wikipedia.
  - Feed forward (open loop) control
    - Shooter tester
  - Feedback (close loop) control
    - Shooter with hall effect speed sensor

Feed Forward Control

Control Variable

Input → | Controller | → | Plant | → Output

X_{cmd} → | C | — X_{ctrl} → | P | → X_{out}
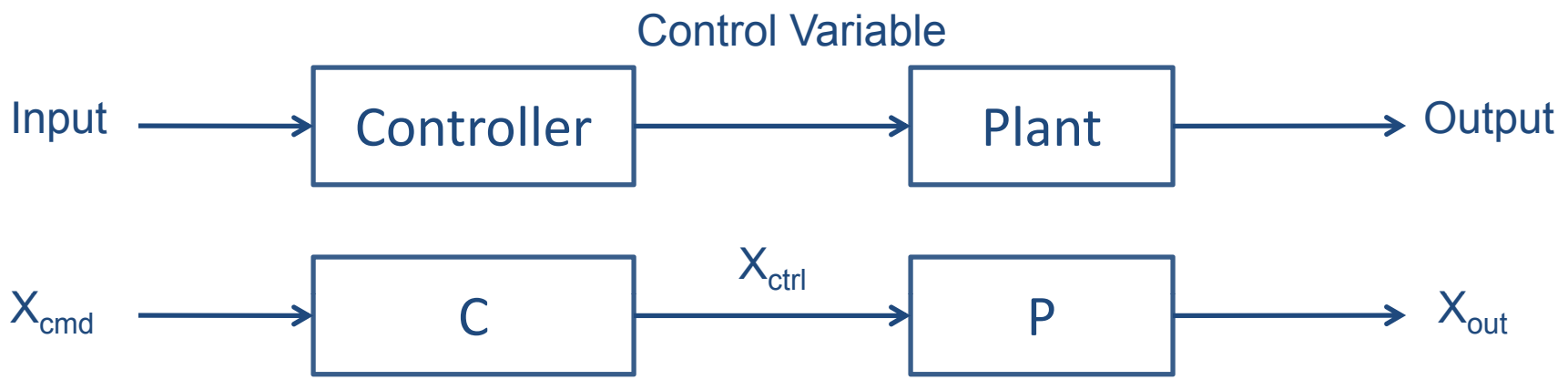
In time domain:
$X_{ctrl}(t) = C(X_{cmd}, t)$
$X_{out}(t) = P(X_{ctrl}, t),$

For a linear system and in frequency domain:
$X_{ctrl}(s) = C(s)X_{cmd}(s)$
$X_{out}(s) = P(s) X_{ctrl}(s) = P(s) C(s) X_{cmd}(s)$
$s = j\omega = j(2\pi f), f$ - frequency

Plant – a physical system to be controlled; robot driving base, shooter wheel
Input – Target/desired value of plant output; robot position, shooter speed, joystick input counts
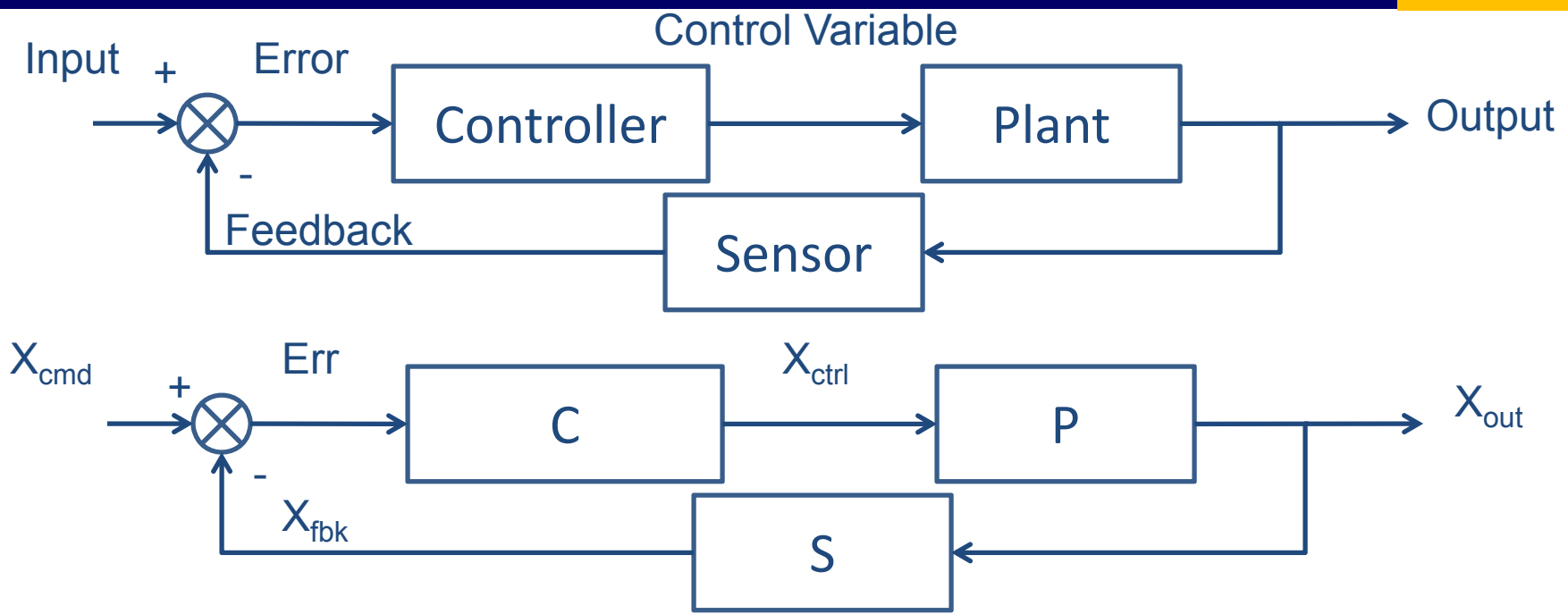Controller – signal converter, conditioner;
Control Variables – Physical signal which plant can take as input; voltage, torque
Output – Physical response of plant to its input.

Feedback Control System

In time domain:

$X_{fbk}(t) = S(X_{out}, t)$

$Err(t) = X_{cmd}(t) - X_{fbk}(t)$

$X_{ctrl}(t) = C(Err, t)$

$X_{out}(t) = P(X_{ctrl}, t),$

For a linear system and in frequency domain:

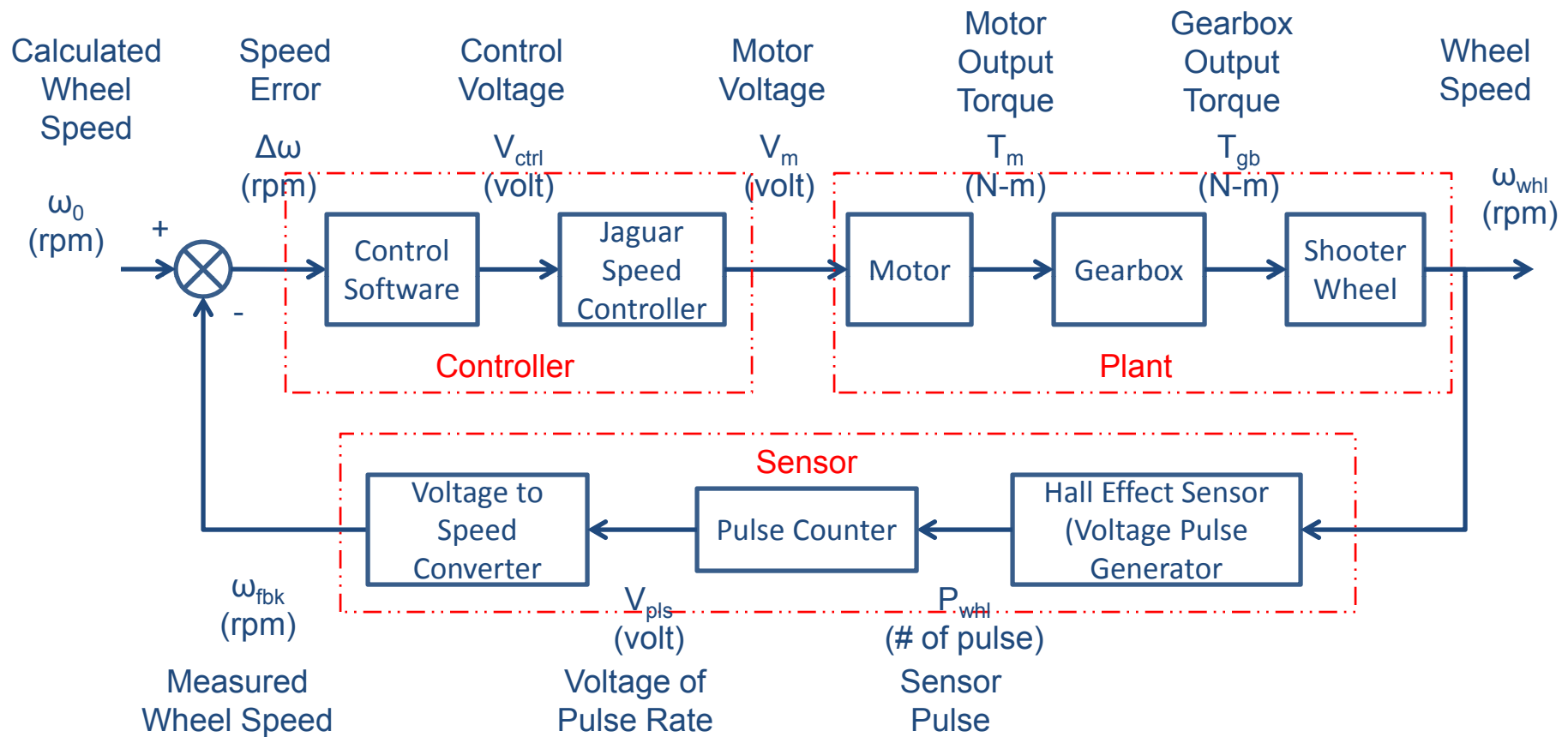$X_{fbk}(s) = S(s) X_{out}(s)$

$E(s) = X_{cmd}(s) - X_{fbk}(s)$

$X_{ctrl}(s) = C(s) E(s) = C(s) [X_{cmd}(s) - X_{out}(s)]$

$X_{out}(s) = P(s) X_{ctrl}(s) = P(s) C(s) [X_{cmd}(s) - X_{out}(s)]$

$\mathbf{X_{out}(s) = \{P(s)C(s) /[1 + P(s) C(s) S(s)]\} X_{cmd}(s)}$

Example

- Present every major component
- Label variables and physical unit
- Label conversion factor

Summary

- Major control system include
    - plant, controller and sensor blocks
- Each block contains many physical components.
- Present physical components with input and output variables.
- Establish math function between input and output of each component with proper unit.

Homework (two weeks)

- Find the conversion factors for each box of shooter control diagram (analytical, experimental, or online search).
- Write done the algorithm (logic steps) of current version of control SW.
- Advanced home work
  - What is block diagram (mathematic relation) of a motor?
  - Is Jaguar a simple proportional components?
  - Besides driving torque, are there any other torques acting on shooter wheel?

Make a Test Fixture for Lecture 2
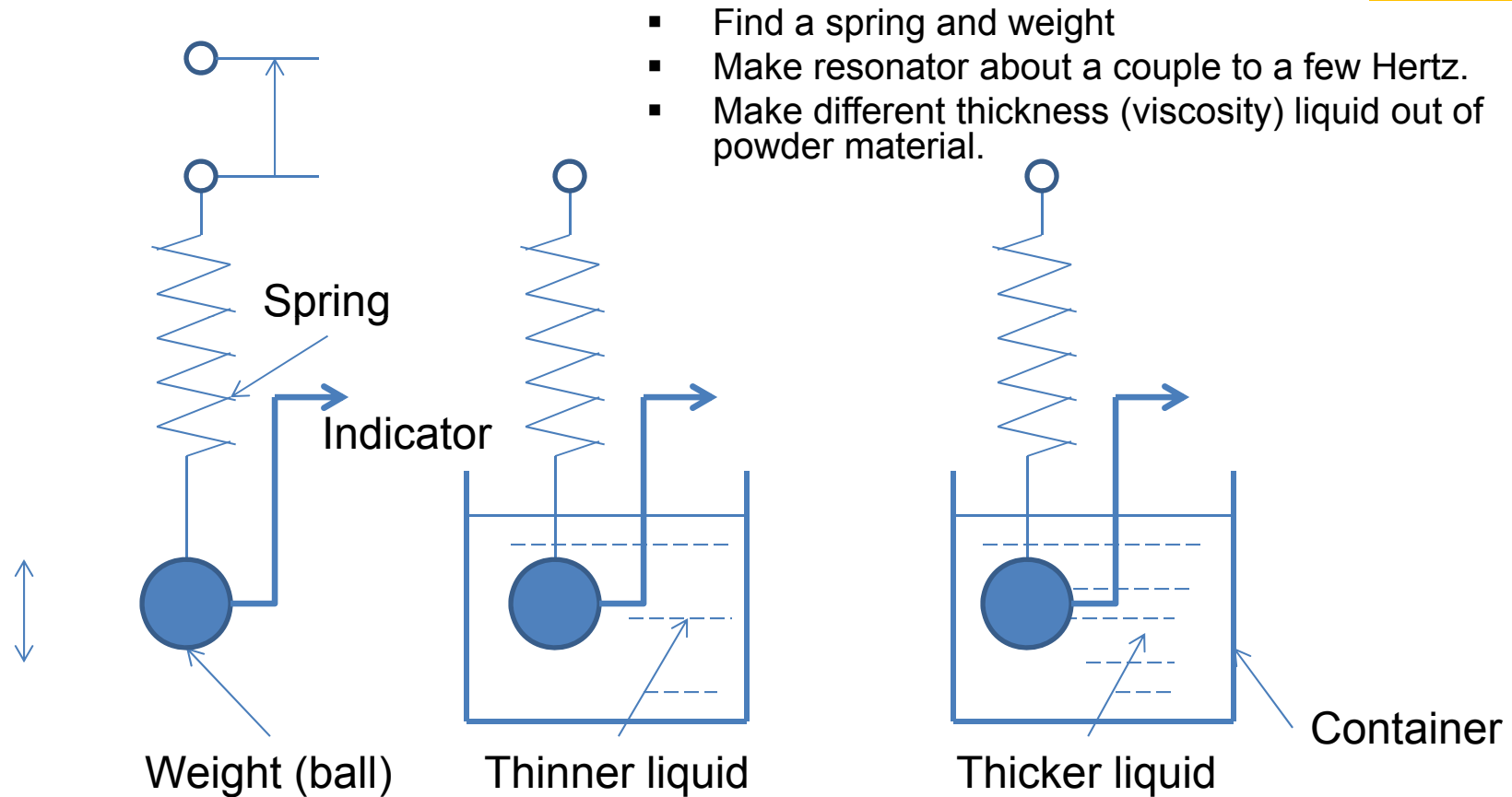
- Find a spring and weight
- Make resonator about a couple to a few Hertz.
- Make different thickness (viscosity) liquid out of powder material.

Spring

Indicator

Weight (ball)   Thinner liquid   Thicker liquid   Container

- Dip weight ball or a rod into liquid.
- Suddenly lift top end of spring a distance.
- Observe weight movement.