

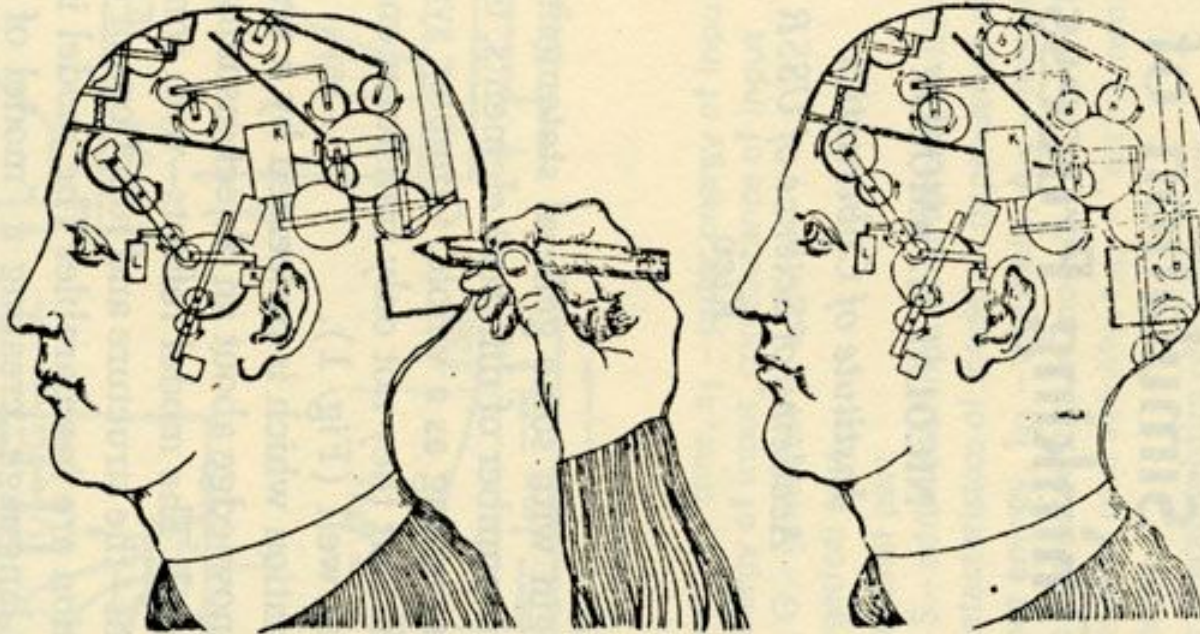
Introduction to Robotics

CSE 461

Lecture 10: Introduction to Control System Theory

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Cybernetics



The term "cybernetics" comes from the Greek word "kybernetes," which means "steersman" or "governor." In cybernetics, this refers to the process of controlling or regulating a system by providing feedback. It involves the study of how systems, both biological and artificial, process information, adapt to changes in their environment, and communicate with each other.

How things get controlled

Control Systems Example

Body temperature regulation

- If cold, shiver (muscles produce heat)
- If hot, sweat (evaporation takes away heat)

Maintaining social peace

- If a crime is found (sensor), the guilty party is punished (actuator).

Cruise control in cars

- You set a speed, Cruise control will increase fuel intake uphill, and decrease it downhill.
- Etc...

Control System Goal

- Regulation
 - Thermostat
- Tracking
 - robot movement, adjust TCP window to network bandwidth
- Optimization
 - best mix of chemicals, minimize response times

Control Theory



Why Control Theory

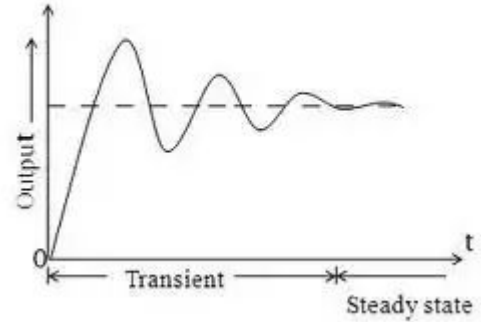
Systematic approach to analysis and design

- Transient response
- Consider sampling times, control frequency Taxonomy of basic controllers (PID, open-loop, Model-based, Feedforward...)
- Select controller based on desired characteristics

Predict system response to some input

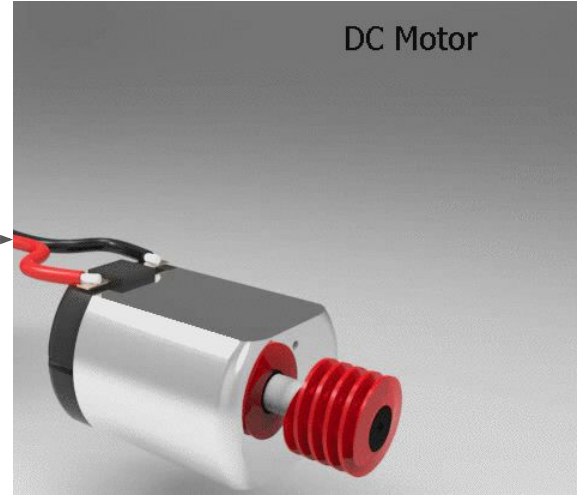
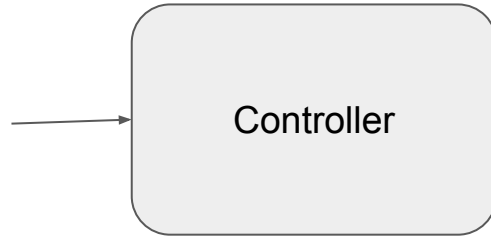
- Speed of response (e.g., adjust to workload changes)
- Oscillations (variability)

Assessing stability of system

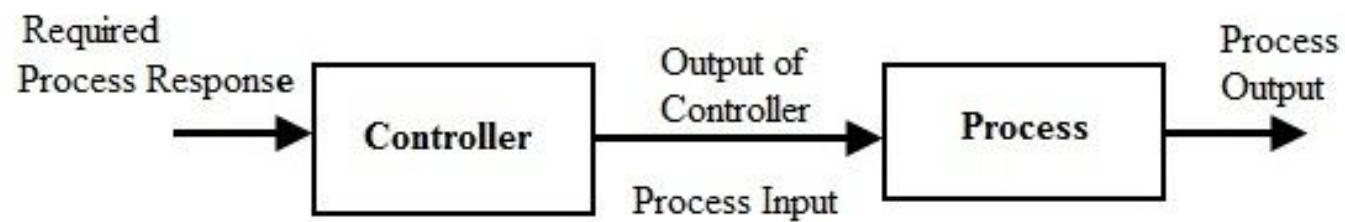


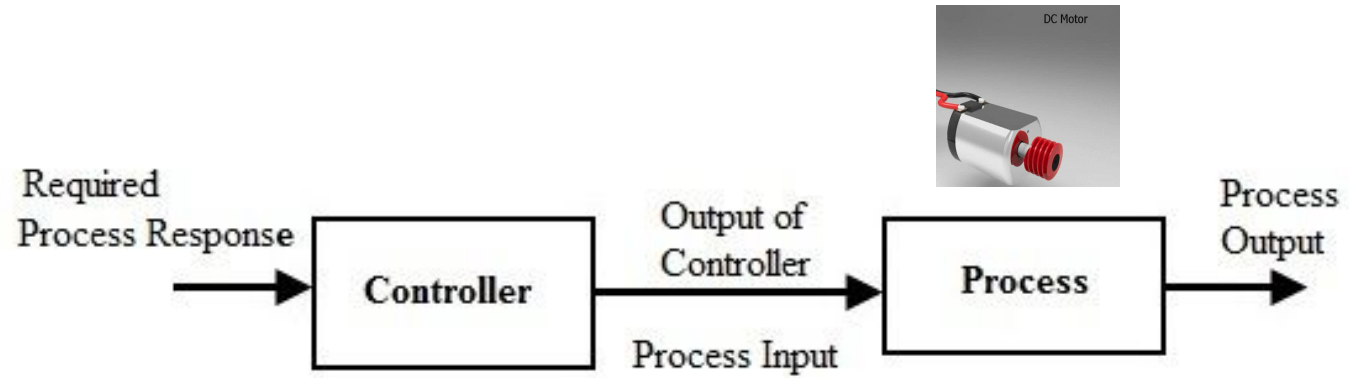
Control System

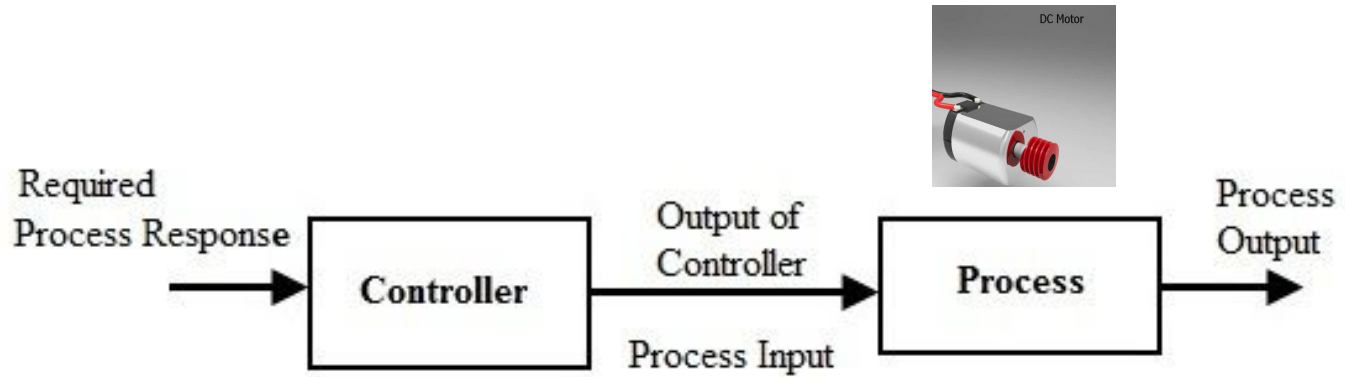
3 rad/sec



2.2 rad/sec

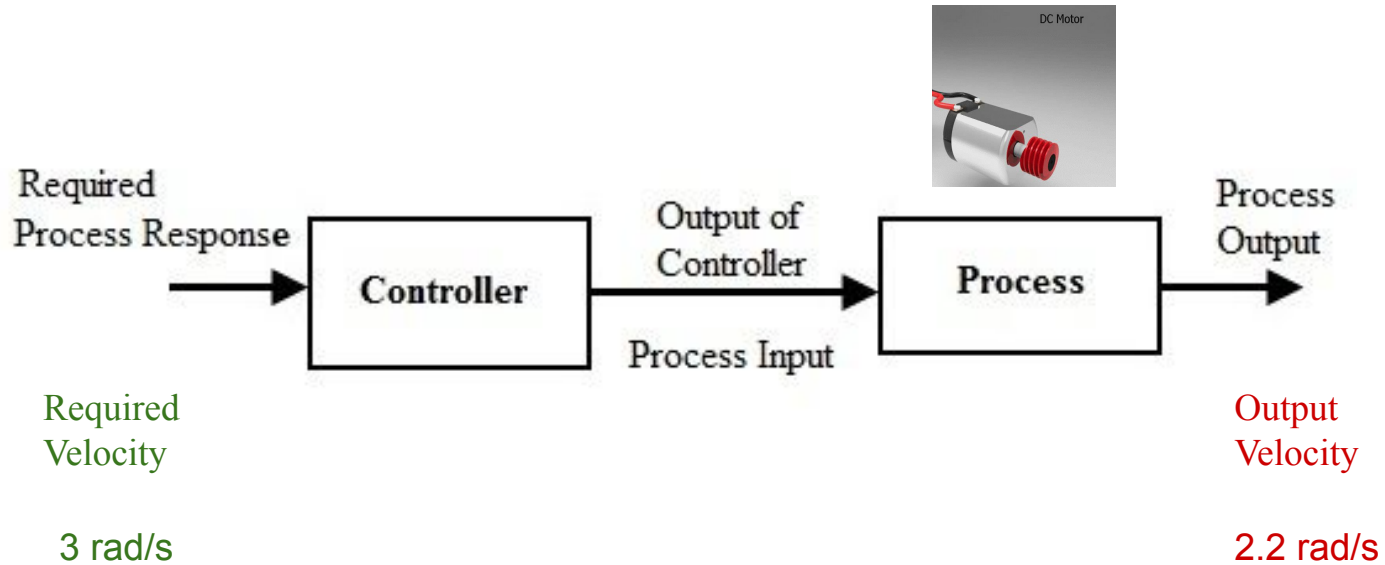




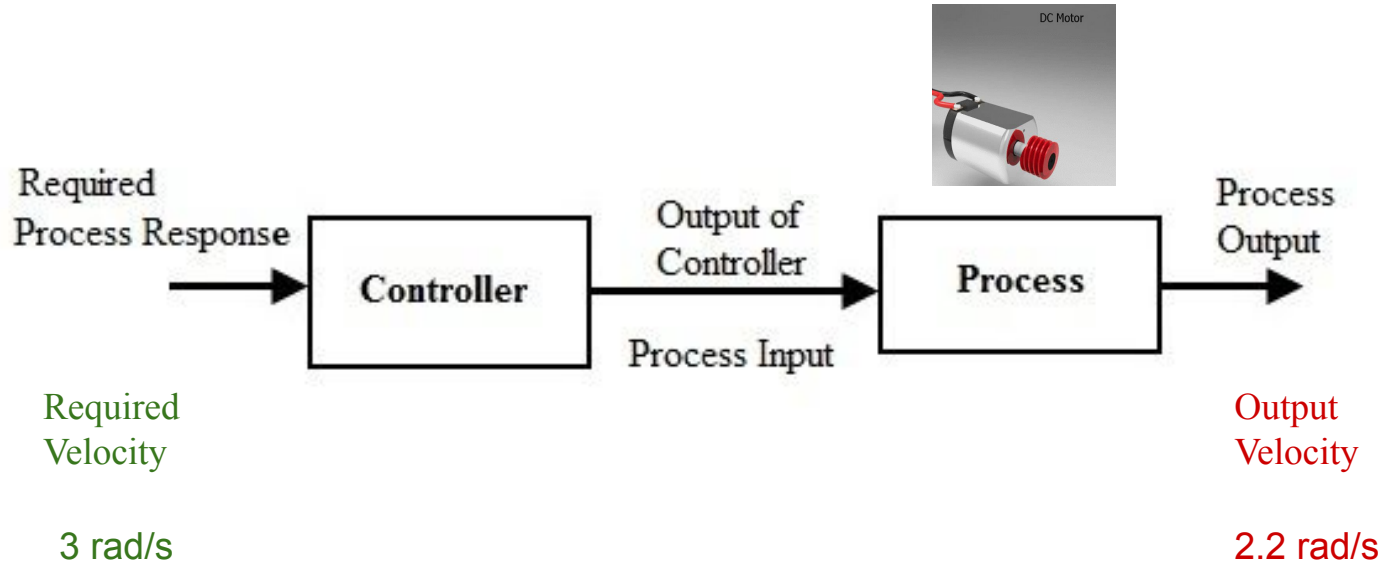


3 rad/s

2.2 rad/s



Open Loop Control

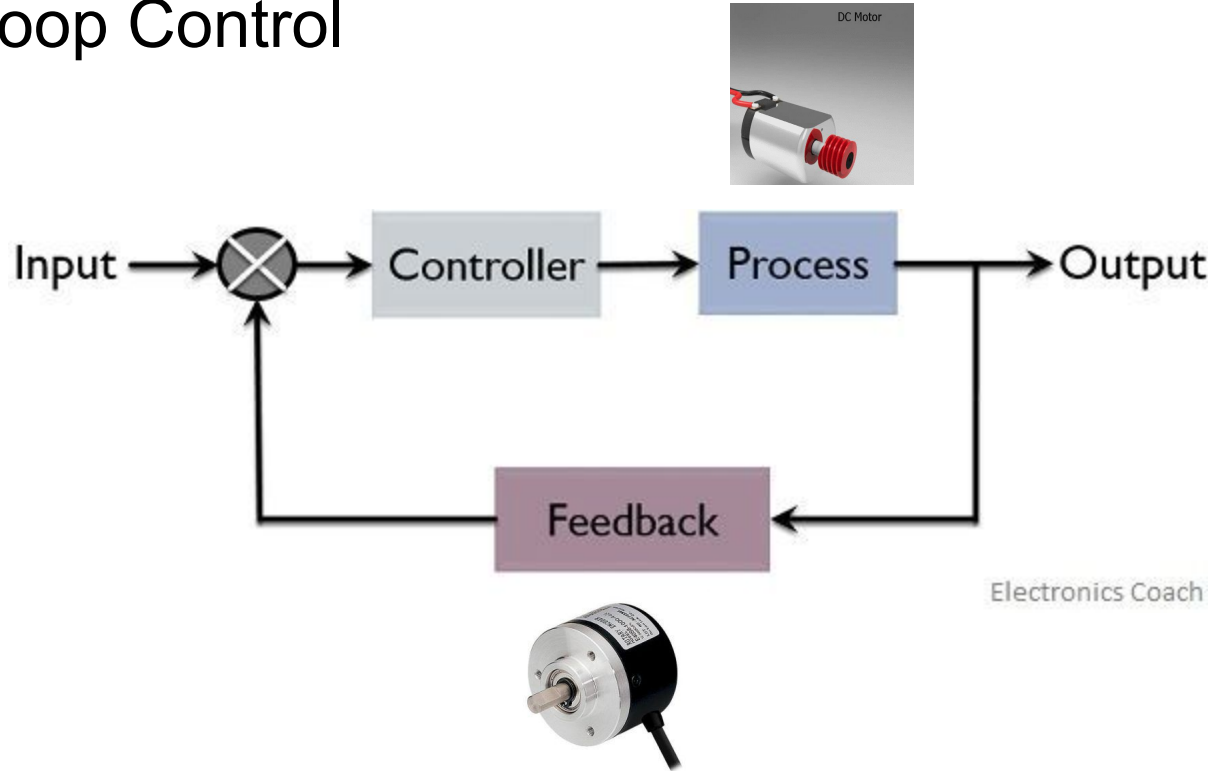


Let's measure the actual angular velocities.

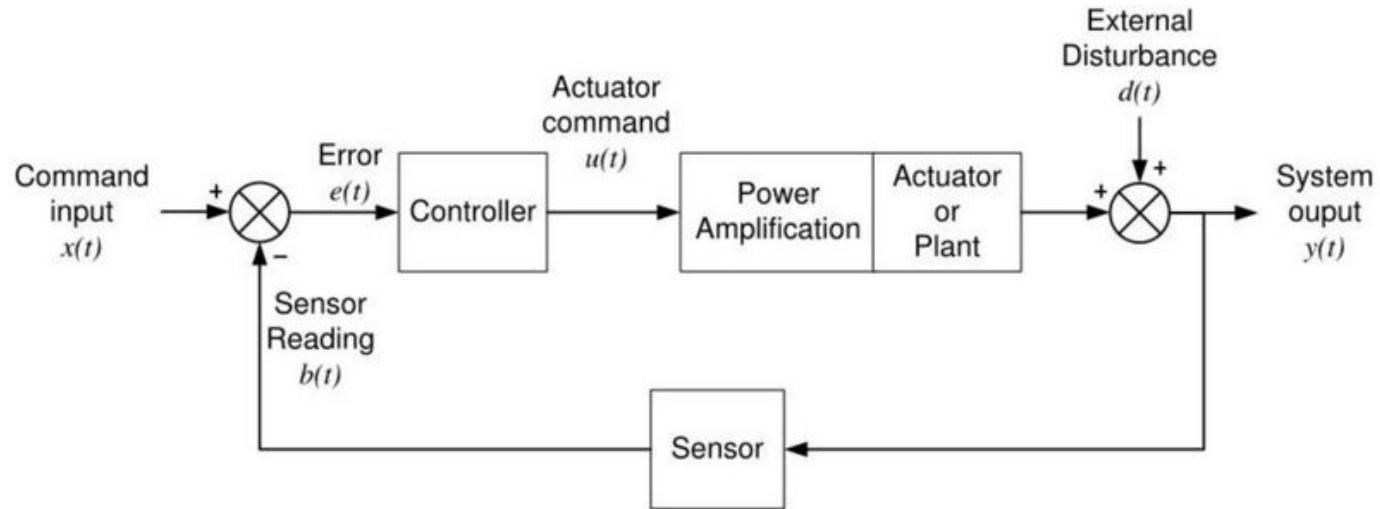
Now we can compensate for changes in load by feeding back some information.



Closed Loop Control



Feedback Diagram



Block Diagram



$$Y = X * G$$

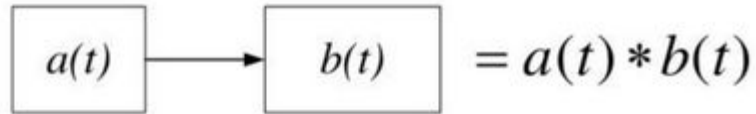
$$Y/X = G$$

$$\text{Gain} = Y/X = \text{Output/Input}$$

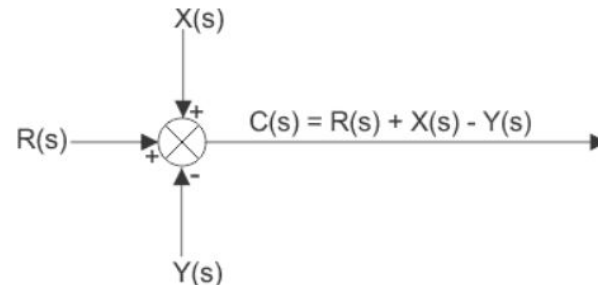
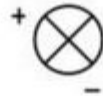
Block Diagram

- Rules

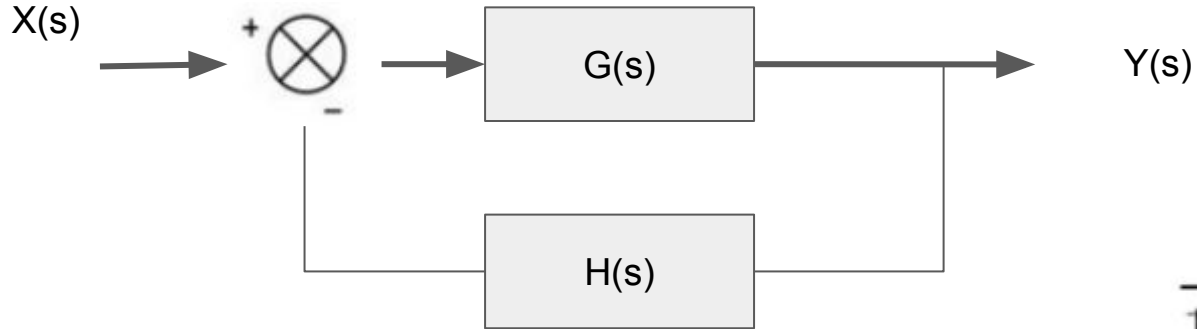
- Cascaded elements: convolution



- Summation and deference elements



- Feedback Connection



$$\frac{G(s)}{1 \mp G(s)H(s)} * X(s)$$

Next Class

How to design a control system

How to solve a block diagram

PID Control

Thank You