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Prelab Questions

1. What is the basic difference between an open and closed-loop control system?
   Open-loop systems use processes or algorithms to directly generate their output states from their inputs. They, however, have no means of measuring the effects of these actions.
   Closed-loop systems use their own output as a secondary input and perform an action based on the error between the desired and current state. Also known as feedback.

2. What does the acronym "PID" stand for?
   Proportional, integral, and derivative.

3. When does proportional control lose effectiveness?
   When the plant output nears the setpoint.

4. Did you watch the intro videos?
   Yes.

Notes

Plant – system we want to control
    Can be thought of as 2 separate parts: actuator and process
    Actuator(s) is the device(s) generating the force/energy required to change the system.
        Ex: motor or a heater
    Process is the object in which the actuator is trying to affect.
Output – has different names: commanded variable, setpoint, reference, desired value
Error – the difference between the input and output
Controller – the part of the system in which decreases the error by some amount.

PID Controllers

Generic PID equation:

$$c(t) = K_p e(t) + K_i \int_0^t e(\tau)d\tau + \frac{K_d\big(de(t)\big)}{dt}$$

$c(t)$ represents the output control
$e(t)$ represents the input error

Proportional Control

Proportional control represents the relationship between the output control signal and the input error.

$$c(t) = K_p e(t)$$

K_p is a constant and the scaling coefficient. It determines the strength of the action required to correct the error signal.
By itself, this control doesn't cover all kinds of situations. It can create a Steady State Error in which the error can never be reduced to zero, only to a very miniscule value.

Integral Control

Basically keeps track of the past.

Keeps a running total of the input over time.
Saturation is where the output of a system hits a limit and stays there.
- This happens to all real-life systems.

Integral Windup – the command exceeds the saturation limit and causes a large gap in which the system needs to unwind when the integral is dropping back down to the desired output.
Anti-windup
- Clamping – turning the integrator off when integration is no longer desired.
  - Compares the value before and after the clamping; if the input and outputs are equal, then the system is not in saturation. If they are not equal, the system *is* in saturation.
  - Also compares the sign of the input to the sign of the output.
  - Comparing the sign and the values determine whether to clamp or not.
  - Also known as conditional integration.
  - Don’t set the saturation limit to the actuator limit. Typically, set it lower, although how low is up to the designer’s discretion.
- Back-calculation
- Observer approach

Derivate Control
“Predicts” the future
Looks at the current change of error to see how quickly the goal is approaching and adjust accordingly.
Prevents the system from overshooting