Process Dynamics and Control

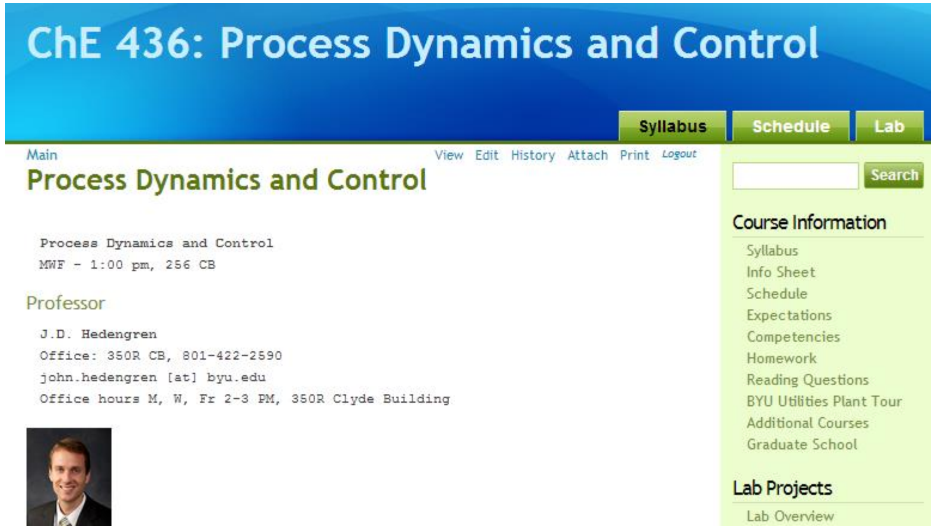
CH EN 436

Dr. John Hedengren

Schedule

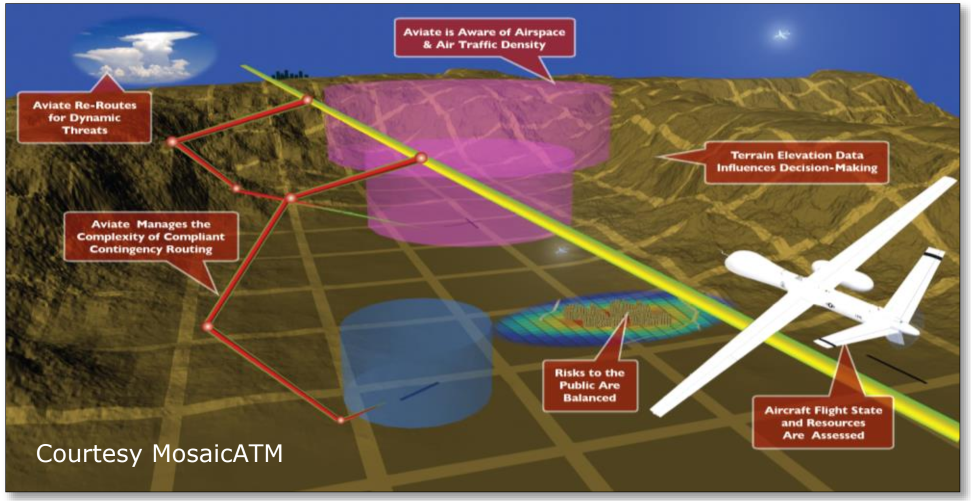
- Course Web-Site

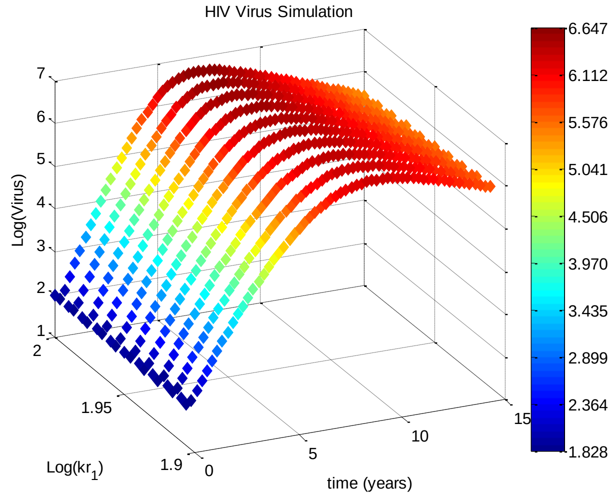
  http://apmonitor.com/che436

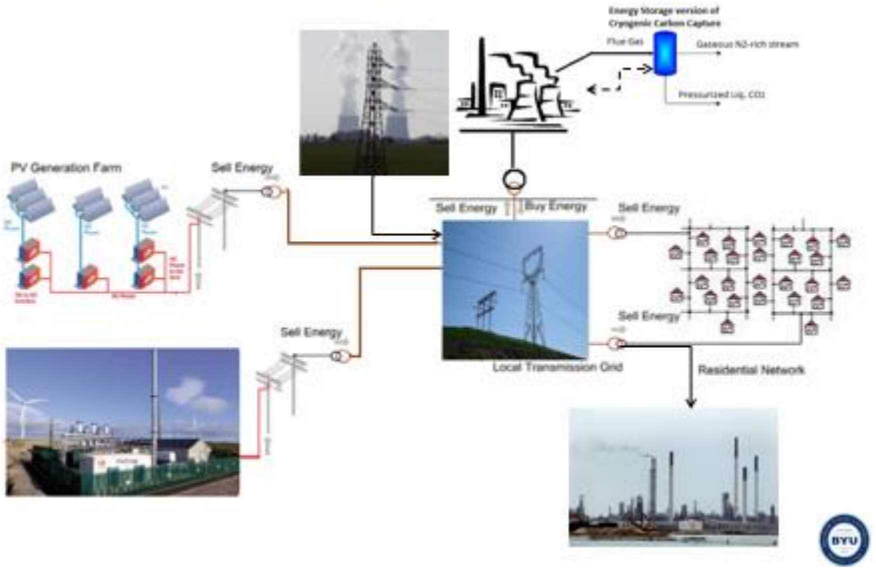


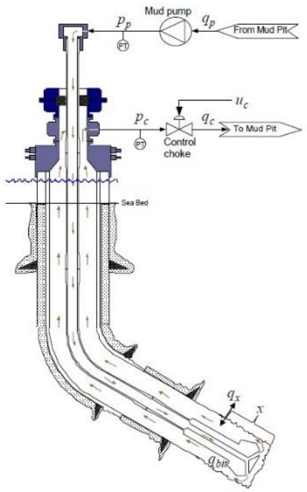
- Course Group Projects
  - Project 1: Arduino Temperature Control
  - Project 2: Simulation Lab
- Teaching Method: Think, Pair, Share

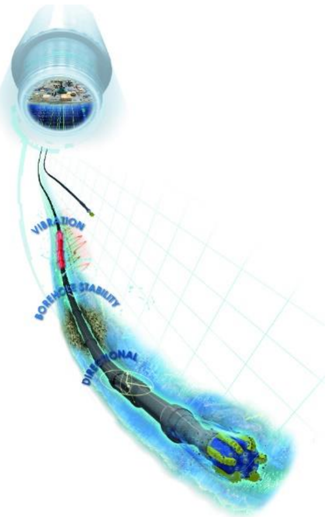
Process Dynamics and Control





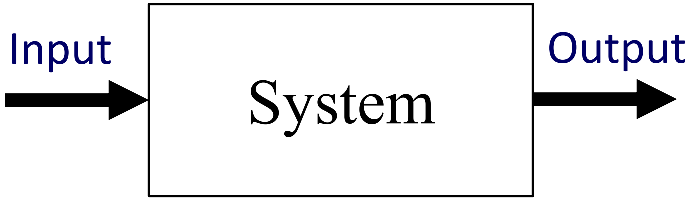






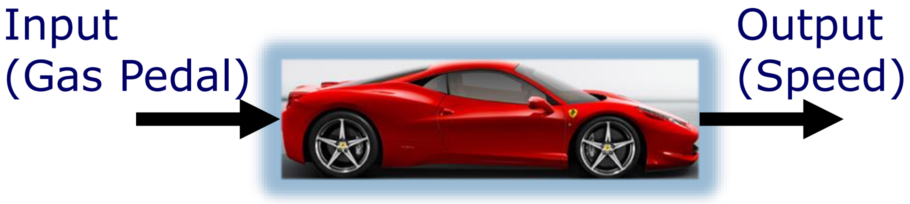
Dynamics and Control

- Dynamic Modeling
  - Empirical Modeling
    - Graphical Approach
    - Optimization Approach
  - Fundamental Modeling
- Controller Design
  - PID
  - Model Predictive Control



- Example: Maintain Speed of Automobile

Dynamic Modeling



Automobile Speed Modeling

- Dynamic Modeling
  - Gain (K_p)
  - Time Constant (τ_p)
  - Apparent Dead Time (θ_p)

First Order Plus Dead-Time (FOPDT)

Input = U(s) → $\frac{K_p}{\tau_p s + 1} e^{-\theta_p s}$ → Output = X(s)

$$\tau_p \frac{\partial x}{\partial t} = -x + K_p u(t - \theta_p)$$

Input
(Gas Pedal)

Output
(Speed)

Dynamic Modeling from Fundamentals

- v = 50 m/s – Desired Velocity
- m = 500 kg (mass)
- b = 50 N-s/m (resistive coefficient)
- K_p = 0.5 m/s / (% gas pedal)
- u = ? (% gas pedal)
- Time delay = 0.5 seconds

Force Balance

$$\frac{m}{b}\frac{\partial v}{\partial t} = -v + K_p\, u(t-0.5)$$

→

FOPDT Model

$$\tau_p \frac{\partial x}{\partial t} = -x + K_p u(t-\theta_p)$$

Automobile Speed Control

- Controller Design

FOPDT Dynamic Model

K_p = Process Gain

τ_p = Process time constant

θ_p = Process dead - time

→

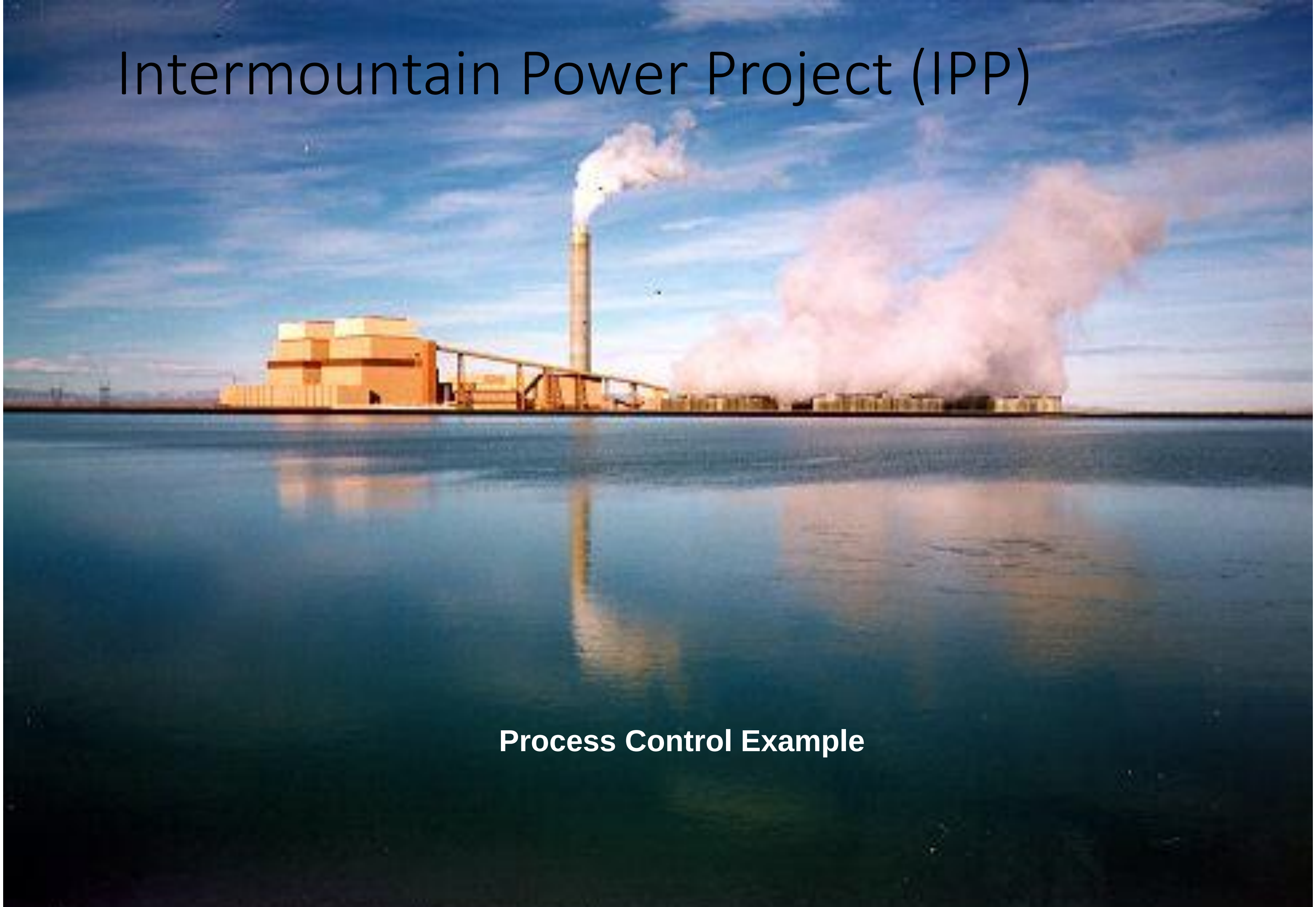
PID Controller

K_C = Controller Gain

τ_I = Integral time constant

τ_D = Derivative time constant

Intermountain Power Project (IPP)



Process Control Example

IPP

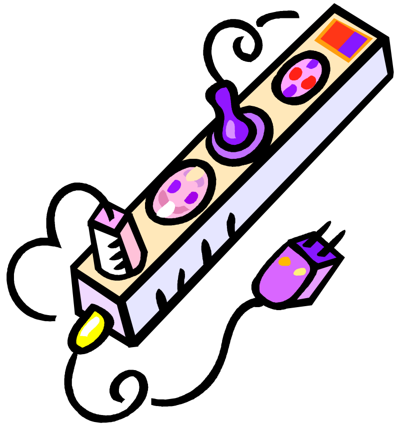
- Two 975 MW boilers
  - 1 million lbs/hr of coal in each boiler
    - 10-15% ash
  - Tight control of NO_x, SO_x, particulate
  - Majority of ash sold for use in concrete
- AC power converted to DC
- All power shipped to LA and re-inverted to AC power

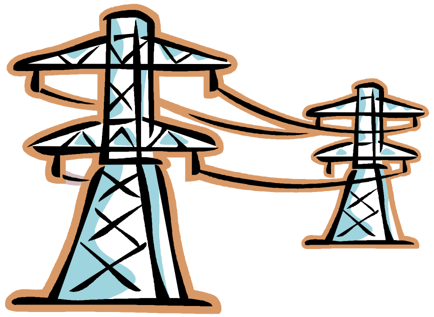
Old Control Room

New Control Room

Suppose the demand for electricity decreases at 11 pm….

- What must be changed to lower the electrical output?





Assignment

- Reading (see Class Schedule)
- Fill Out Info Sheet, Q1.1 (PPC)
  - http://apmonitor.com/che436/index.php/Main/InfoSheet
- Write objective / course competency met
- Note examples of controllers around you
  - See YouTube video in Lecture 1
  - Try MATLAB / Simulink Exercise
- Dean’s Lectures
  - 2 required to avoid ½ grade penalty (B+ to B)