UNIVERSITY of DELAWARE

# Perspectives on Undergraduate Process Control Education

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# Outline

- **Introduction**
  - What is “Process Control”
  - Why “Undergraduate Process Control”
- **Current State**
  - What and Why
  - How
- **Considerations for the 21st Century**
- **Conclusions**

# introduction

# What is Process Control

- **Engineering Discipline**
  - Deals with architectures, mechanisms and algorithms for maintaining the output of a process within a desired range.
  - Belongs to the family of topics collectively known as *Automation/Control & Systems Theory*; shared with other engineering disciplines (ME, EE, Aerospace, etc.)
- **Components**
  - Research; Applications;
  - Education: Undergraduate and Graduate (focus on undergraduate education)

# Historical Perspectives

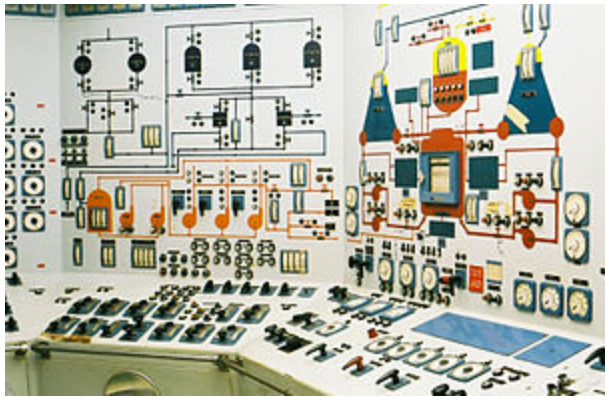
- **18th and 19th Century**
  - Dominant Science: ***Physics***
  - Technological Innovations and the role of Automation/Control and Systems Theory
- **20th Century**
  - Dominant Science: ***Chemistry***
  - Technological Innovations and the role of Automation/Control and Systems Theory
- **21st Century**
  - Dominant Science: ***Biology*** (incl. ***Information Sciences***)
  - Technological Innovations and …. ?

# Historical Perspectives

- **Centrifugal Flyball Governor**
  - Invented in 1788 by James Watt to control his steam engine
  - Regulates the admission of steam into the cylinder(s).

# Why Teach Process Control

- **The only place where students are exposed to dynamics.**
  - Other course in the Chem E curriculum deal with steady state analysis and design
- **Remains an important aspect of industrial practice**
  - No industrial process can operate successfully without an effective control room
- **Principles applicable to other non-Chem E disciplines**
  - Finance & Economics
  - Biology and Medicine



# current state

# What

- **Control course eliminated in some schools**
- **Not required in others**
  - even @ MIT with Braatz and Stephanopoulos!
- **When still required, often taught by "non-experts"**

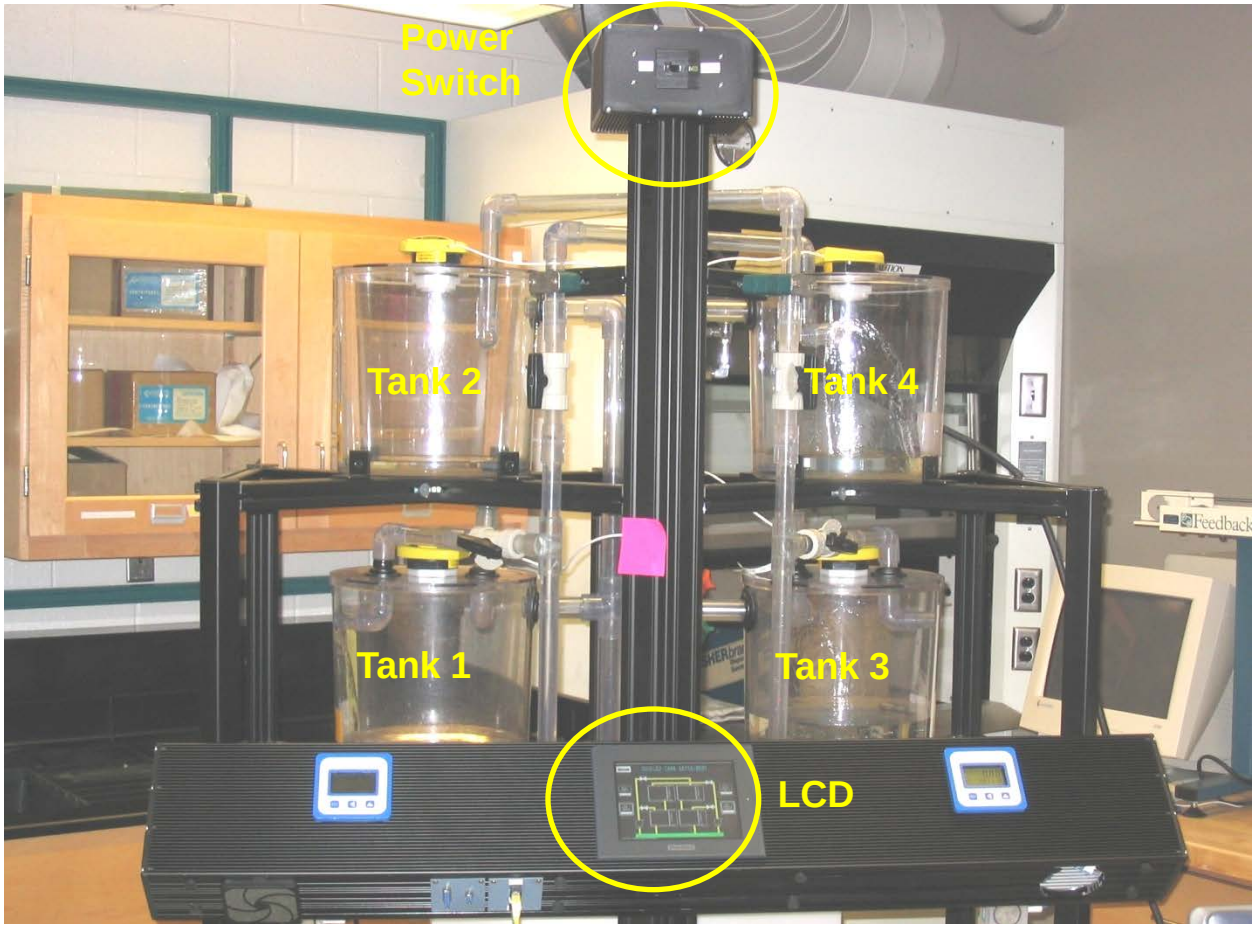
# Why

- **Alarming number of Chem E departments have only one "Systems" faculty**
- **Not enough new faculty with interest and expertise in "Systems" being produced**
- **Research Funding**
- **Etc.**

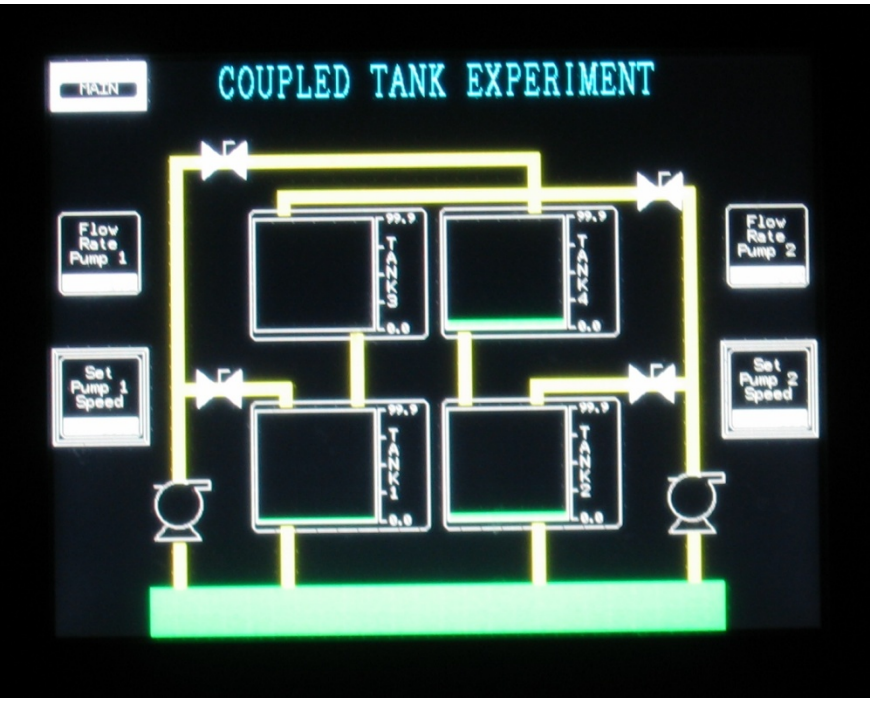
# How
# (we currently teach the course)

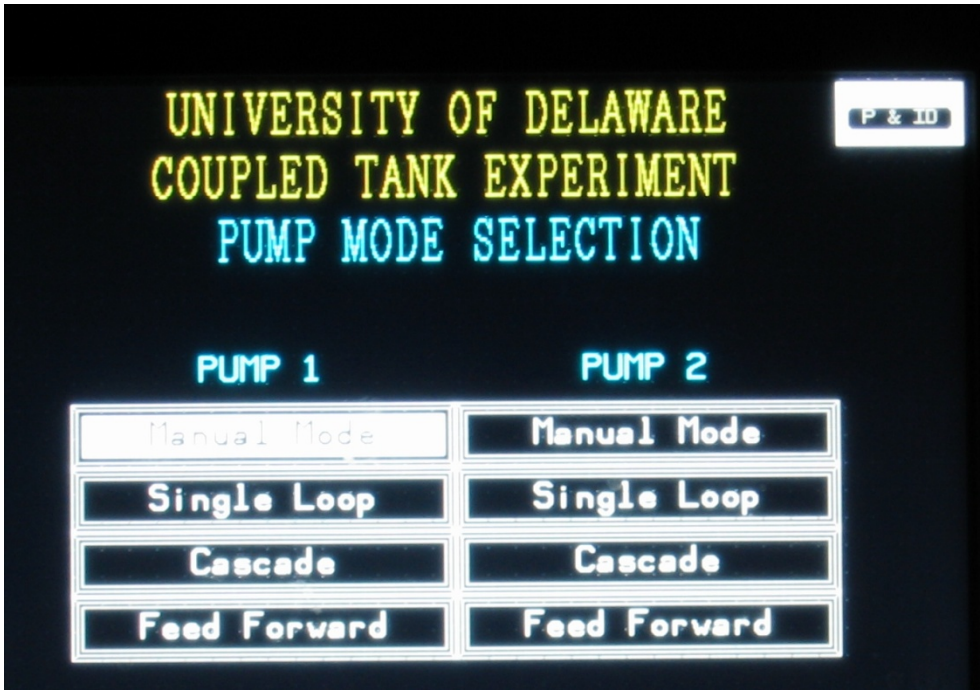
- **Mostly (but not always) too theoretical**
- **Too much emphasis on less relevant material**
- **Not as connected to industrial practice**
- **But… some institutions get it right**
  - Right mix of topics (adaptable and evolving)
  - Right mix of theory and experiments
  - Appropriate pedagogic tools
  - Appropriate balance in problem sets and exams

# Physical Apparatus @ UD



# Control System Screens



# considerations for the 21st century

# Driving Forces for 21st Century

- **Grand Challenges**
  - What are the grand challenges of the day?
  - What is driving these challenges?
- **Dominant Science**
  - What is the dominant science driving technological solutions of the day?
  - What is the role of Process Control/Systems Analysis in enabling these solutions?
- **Technology for Pedagogy**
  - How should pedagogical technology affect the way we teach Process Control in this century?

# How Should We Teach Process Control

- **Curriculum Content: What it should achieve**

  *(Prepare students for the next stage (industry/grad school))*

  - Understand the need for control; economic implications
  - Understand principles of "Systems Analysis"
  - Understand applications of the principles to various traditional and non-traditional problems
  - Can acquire and analyze data in the context of systems understanding, and the role of uncertainty
  - Can design, implement, and analyze performance of control systems (single unit/plant-wide)
  - Can extrapolate basic knowledge to more complex, previously unexplored circumstances

# How Should We Teach Process Control

- **Implications for Topics to Cover**
  - Return to basic, universal principles
    - ✧ Dynamics; Modeling; Control
  - Dynamic Analysis (implications for controller design)
  - Modeling and Identification
  - Controller Design
    - ✧Basic Principles of Feedback
    - ✧Other configurations: what, why and how
  - Non-traditional examples (Finance; Biomedical—intrinsic and extrinsic)
  - Process Data Acquisition and Analysis

# How Should We Teach Process Control

- **Examples of Topics/Applications to Consider**
  - Biological Control Systems
    - ✧Intrinsic vs Extrinsic
    - ✧Pathology and Treatment
  - Financial Engineering
  - Micro-manufacturing
  - SCADAS (Supervisory Control and Data Acquisition Systems)
    - ✧Structure/Configuration
    - ✧Cybersecurity

# Examples of Non-Traditional Applications

- **Calcium Homeostasis**
  - Intrinsic
  - Illustrates a control engineering perspective of a biological system
  - Provides control engineering perspective of pathology and diagnosis
- **Hemostasis: Platelet Count Control**
  - Extrinsic
  - Illustrates how traditional control engineering can be used for the design of an effective control system for medical applications

# How Should We Teach Process Control

- **Curriculum Delivery**
  - Use Technology (simulations software, etc.); augment with experimentation
  - Use Case Studies (Traditional and non-traditional)
  - Insert industrial guest lecturers where possible
  - Use novel pedagogical tools
    - ✧PBL
    - ✧ Flipped Classroom
    - ✧UD Second mid-term exam format
  - Tutorial sessions

# conclusion

# Conclusion

- **Historically**
  - Process Control/Systems Analysis enabled technological advances of past centuries;
  - No reason it cannot do the same in this century
- **Manpower Development**
  - Work with industry and funding agencies to produce new generation faculty
- **Curriculum Content & Delivery**
  - Adapt appropriately to be relevant

# THANK YOU!