Approval: 9th Senate Meeting

Course Name:	Industrial Process Control
Course Number:	EE - 618
Credits:	2.5-0.5-0-3 (L-T-P-C)
Prerequisites:	EE 514 Linear Dynamical Systems or teachers consent
Intended for:	U.G. and P.G.
Distribution:	Elective
Semester:	Even

Course Preamble:

Process control has become increasingly important in the process industries as a consequence of global competition, rapidly changing *economic* conditions, and more stringent environmental and *safety* regulations. It is a sub-discipline of automatic control that involves tailoring methods for *efficient* operation of industrial processes. Control engineers are often responsible for the operation of industrial processes. As these processes become larger scale and/or more complex, the role of process automation becomes more and more important. Proper application of process control improves the safety and profitability of a process, while maintaining consistently the *desired product quality*. The automation of selected functions have relieved plant personnel of tedious, routine tasks, providing them with time and data to monitor and supervise operations in real-time.

Course Outline:

This course aims to provide in-depth understanding of designing and implementing practical control strategies in process industries.

Course Learning Outcomes:

At the completion of this course, students will be able to:

- Understand the basic principles & importance of process control in industrial process plants;
- Specify the required instrumentation and final elements to ensure that well-tuned control is achieved;
- Understand the use of block diagrams & the mathematical basis for the design of control systems;
- Design and tune *process* (PID) controllers;
- Use appropriate software tools for the modelling of plant dynamics and the design of well tuned control loops;

- Understand the importance and application of good instrumentation for the efficient design of process control loops for process engineering plants.
- Understand the experimental implementation of advanced process control schemes and the methods for process monitoring and diagnosis.

Course structure:

1. Introductory concepts of Process control [3 lectures]
   The Chemical Process, An Industrial Perspective of a Typical Process Control Problem, Variables of a Process, The Concept of a Process Control System, Introduction to Control System Implementation, Instrumentation, Material and Energy Balances, Form of Dynamic Models, Linear Models and Deviation Variables.
2. Process dynamics, modelling and identification [6 lectures]
   Models for dynamical systems, Similarity transformations and minimal representations, Analysing linear dynamical systems, Development of Theoretical Process Models, Parameter Estimation, Validation of Theoretical Models, Principles of Empirical Modelling, Step-Impulse-Frequency response Identification, Closed-loop stability, Control performance in different frequency ranges, Unstable systems, Limitations due to uncertainty in the plant model and input constraints.
3. Single-loop and multivariable process control [12 lectures]
   Control loop structures for the regulatory control layer, Feedforward control, Ratio Control, Cascade control, Auctioneering control, split range control, parallel control, Controller tuning using Fundamental process models, approximate process models, frequency response models, tuning without a Model, Design of More Complex Control Structures, Controller Design for Processes with Difficult Dynamics, Controller Design for Nonlinear Systems, Nature of Multivariable Systems, Open-Loop and closed loop Dynamic Analysis, Relative Gain Array, Loop Pairing and shaping, Decoupling, Steady-State Decoupling by Singular Value analysis, Model-Based Controllers for Multivariable Processes, Tuning of decentralised controllers.
4. Control structure selection and plant-wide control [5 lectures]
   Top-down analysis, bottom-up design, regulatory control, determining degrees of freedom, selection of controlled variables based on local analysis, selection of manipulated variables, mass balance control and throughput manipulation, economic considerations in plantwide control.
5. Model-based predictive control [6 lectures]
   Formulation of a QP problem for MPC, step response models, updating the process model, Kalman filters, disturbance handling and off-set free control, feasibility and constraint handling, closed-loop stability with MPC controllers, target calculation, robustness of MPC controllers.
6. Special topics in process control [6 lectures]
   Discrete time implementation - aliasing - sampling interval, pure integrators in parallel, anti-windup control, Hanus's self conditioned form, observer-based controllers, bumpless transfer, nonlinear systems - methods of dynamical analysis and linearization, basics of

process monitoring and diagnosis, linear regression techniques applied in process control - principal component analysis - partial least squares - Fourier-Motzkin elimination.

7. Lab Exercises [4 lectures]
   Experiments on process control applications on water tank system, robotic arm, etc.

Textbooks:

1. B. A. Ogunnaike, W. H. Ray, Process Dynamics, Modelling and Control, Oxford University Press, 1994.
2. D. E. Seborg, T. E. Edgar, D. A. Mellichamp, Process Dynamics and Control, John Wiley and Sons, 2004.

References:

1. B. W. Bequette, Process Control: Modeling, Design, and Simulation, Prentice Hall International Series, 2002.
2. F. G. Shinskey, Process Systems: Application, Design and Adjustments, McGraw Hill, 1967.