Subject Code: 01CH0504
Subject Name: Instrumentation & Process Control
B.Tech. Year – III (Semester-5)

Objective: This course introduces dynamic processes and its control. Subject deals with modelling, static, dynamic behaviour of processes and its control strategies; design of feedback, feed forward, and other control structures.

Credits Earned: 5 Credits

Course Outcomes: After completion of this course, student will be able to:

1. To build basic knowledge and Understand the importance of process dynamics (Steady & unsteady state operation).
2. Able to Design a control strategy for key unit operations (reactor, distillation column, etc)
3. Analyse, design and tune feedback / feed forward controllers in the context of various control strategies used to control chemical and biological processes.
4. Recognize and fit various simple empirical models that are used for designing controllers.
5. Understand working principles of basic instruments available for flow, pressure, level and temperature measurement

Pre-requisite of course: Basics of differential equations, material and energy balance.

Teaching and Examination Scheme

Teaching Scheme (Hours)			Credits	Theory Marks			Tutorial/ Practical Marks		Total Marks
Theory	Tutorial	Practical		ESE (E)	CSE	Internal (I)	Viva (V)	Term work (TW)	
4	0	2	5	50	20	30	25	25	150

Theory Contents:

Unit	Topics	Contact Hours
1	**Introduction to Process Control** Motivation, Importance with examples, Classification of variables with examples, Control configuration, Component of control system.	3
2	**Mathematical Modelling** Development of mathematical models, Modelling considerations for control purpose, Linearization of nonlinear systems.	4
3	**Laplace Transforms** Definitions, Laplace transforms od some basic functions, Laplace transforms of derivatives, Final & Initial value theorem.	3

4	**Dynamic Behaviour of first, Second and higher order systems** Mercury thermometer, Physical examples of first order systems: Liquid level, Non interaction & Interacting system, Physical examples of Second order systems: simple manometer, Step response & impulse response for $\zeta<1$, $\zeta>1$& $\zeta=1$, Overshoot, Decay ratio, Rise time, Response time, Period of oscillation, Natural period of oscillation, Sinusoidal response, Transportation lag, N-first order processes in series, Processes with dead time.	10
5	**Feedback control Schemes** Concept of Feedback control, Types of Feedback controllers, Measuring Devices, Final Control Elements, Block Diagram and Closed loop response, Servo problem v/s regulator problems, Effect of Proportional, Proportional Integral & Proportional Integral derivative Controller on the response of a Controlled Process.	10
6	**Stability Analysis of Feedback Systems** Notion of Stability, The characteristic Equation, Routh-Hurwitz Criterion for stability, Root locus Analysis.	6
7	**Frequency response Analysis** Response of a First order System to a sinusoidal Input, Bode Diagrams, Nyquist Plots, Bode Stability Criterion, Gain & Phase Margin, Ziegler-Nichols Tuning Techniques, Nyquist stability Criterion.	6
8	**Instrumentation** Basic measurement devices and working, principles for level, flow, pressure and Temperature measuring Devices.	6
	Total Hours	48

List of Experiments:

1. To know the hardware element of closed loop control system.
2. To determine the dynamics of given thermometer and compare the theoretical value of the time constant with experimental value.
3. To determine the dynamics of liquid level in a tank and compare the experimental value of time constant with the experimental value. (for step input)
4. To determine the dynamics of liquid level in a tank and compare the experimental value of time constant with the experimental value. (for Impulse)
5. To determine the response of two first order system (tank) in series of the non – interacting system. (For Impulse)
6. To determine the response of first order system in series of the interacting system (For step input).

7. To determine the response of first order system in series of the two interacting system. (for Impulse disturbance).
8. To develop approximation for nonlinear model to be linear & study the dynamics of liquid tank.
9. To determine the Control valve characteristic.

References:

1. George Stephanopoulos, "Chemical Process Control", Prentice-Hall India.
2. Coughanower and Kappel, "Process System Analysis & Control", Mc-Graw Hill Book Company.
3. R. P. Vyas "Process Control and Instrumentation", Denett & Co.
4. Donald .P. Eckman, "Industrial Instrumentation" , John Wiley & Sons Inc

Suggested Theory distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation					
Remember	Understand	Apply	Analyse	Evaluate	Create
10%	20%	25%	25%	10%	10%

Instructional Method:

a. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.
b. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
c. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
d. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Online Web Resources:

a. http://nptel.ac.in/courses/103107123/
b. https://ocw.mit.edu/courses/audio-video-courses/#chemical-engineering
c. https://www.youtube.com/watch?v=GO8HkEZlb9k

Design Based Problems (DP)/ Open Ended project (OEP):

In the beginning of the session, subject faculty will allot an OEP / DP to the students. Students will be free to choose a topic of their choice which will be relevant to the syllabus and they will either prepare a working model/ report / presentation / poster on their topic.