GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Applied Instrumentation

Subject Code : ME02067061

Subject Name : System Dynamics and Modeling

WEF Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite :	Process Modeling and Dynamics, Control Theory
Rationale :	This course provides an overview and fundamentals of various types of systems Dynamics andtheir modeling techniques.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level*
01	Understanding structure of various types of Process models	UN
02	Applying structure of various types of process models, Discrete time Process models in various systems	AP
03	Design system related to study dynamic behavior using system identification techniques	CR

*RM: Remember, UN: Understand, AP: Apply, AN: Analyze, EL: Evaluate, CR: Create

Course Scheme :

Teaching Scheme			Total Credits	Assessment Pattern and Marks				Total Marks
				Theory		Practical		
L	T	PR	C	ESE (E)	PA(M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Course Content:

Sr. No.	Course Content	No. of Hours	% of Weightage
1	**Introduction** An Example of Process Control , Process, Steady-State Process Control, Dynamical Properties of the Process, Feedback Process Control, Transient Performance of Feedback Control, Block Diagram, Feedforward Control, Development of Process Control	10	22
2	**Mathematical Modelling of Processes** General Principles of Modeling, Examples of Dynamic Mathematical Models, Liquid Storage Systems, Heat Transfer Processes, Mass Transfer Processes, Chemical and Biochemical Reactors,General Process Models,Linearisation ,Systems, Classification of Systems.	4	9
3	**Analysis of Process Models** The Laplace Transform, Definition of the Laplace Transform, Laplace Transforms of Common Functions, Properties of the Laplace Transform, Inverse Laplace Transform, Solution of Linear Differential Equations by Laplace Transform Techniques, State-Space Process Models, Concept of State, Solution of State-Space Equations, Canonical Transformation, Stability, Controllability, and Observability of Continuous-Time Systems, Canonical Decomposition Input-Output Process Models, SISO Continuous Systems with Constant Coefficients, Transfer Functions of Systems with Time Delays, Algebra of Transfer Functions for SISO Systems, Input Output Models of MIMO Systems – Matrix Input Output Models of MIMO Systems – Matrix of Transfer Functions, BIBO Stability, Transformation of I/O Models into State- Space Models, I/O Models of MIMO Systems - Matrix Fraction	5	11
4	**Dynamical Behaviour of Processes** Time Responses of Linear Systems to Unit Impulse and Unit Step, Unit Impulse Response, Unit Step Response, Computer Simulations, The Euler Method, The Runge-Kutta method, Runge-Kutta Method for a System of Differential Equations, Time Responses of Liquid	4	9

	Storage Systems, Time Responses of CSTR, Frequency Analysis, Response of the Heat Exchanger to Sinusoidal Input Signal, Definition of Frequency Responses, Frequency Characteristics of a First Order System, Frequency Characteristics of a Second Order System, Frequency Characteristics of an Integrator, Frequency Characteristics of Systems in a Series, Statistical Characteristics of Dynamic Systems, Fundamentals of Probability Theory, Random Variables, Stochastic Processes, White Noise , Response of a Linear System to Stochastic Input, Frequency Domain Analysis of a Linear System With Stochastic Input.		
5	**Discrete-Time Process Models** Computer Controlled and Sampled Data Systems, Z – Transform, Discrete- Time Transfer Functions, Input-Output Discrete-Time Models – Difference Equations, Direct Digital Control, State-Space Discrete-Time Models, Properties of Discrete-Time Systems, Stability, Controllability, Observability, Discrete-Time Feedback Systems – Control Performance Discrete-Time Model of Two Tanks in Series e, Examples of Discrete-Time Process Models, Discrete-Time Tank Model, Discrete-Time Model of Two Tanks in Series, Steady-State Discrete-Time Model of Heat Exchangers in Series.	7	16
6	**Process Identification** Models of Linear Dynamic Systems, Identification from Step Responses, First Order System, Underdamped Second Order System, Underdamped Second Order System, System of a Higher Order, Least Squares Methods, Recursive Least Squares Method, Modifications of Recursive Least Squares, Identification of a Continuous-time Transfer Function.	5	11
7	**System Identification** Introduction, Least squares Estimation, Linear model for Least squares Estimation, Least squares Problem :Formulation and solution, covariance, covariance in stationary,ergodic processes, white noise, detection of periodicity through ACF,detection of transmission delays using ACF,covariance of zero mean processes through convolution,ARMA Processes, mixed notation, what is ARMA Processes?, moving average processes, is unique estimation possible?, auto regressive processes, auto regressive moving average processes, Nonparametric models,covariance between signals of LTI systems, frequency response of LTI systems excited by white noise, prediction	10	22

	error models, one step ahead prediction error model, finite impulse response modular Input model,ARMAX input model,ARIMAX input model, output error model,box- jenkins model, case study : Drifting Noise model, Revisiting Least Squares Estimation, Statistical Properties of Least squares Estimate, Recursive Least Squares, Weight Selection For Iterative Calculations		
	Total	**45**	**100**

Reference Book:

1. Process Modelling, Identification, and Control by Ján Mikleš · Miroslav Fikar , springer
2. Digital Control by Kannan M. Moudgalya , Wiley Interscience

Suggested Course Practical List:

Student has to prepare computer programs and simulations for various system modeling and identification techniques covered in this course with any computing tools (MatLab, Scilab, etc...).

Prepare research paper and submit report of various system modeling techniques covered in this course with presentation.

1. Modeling of electrical machines using system identification techniques.
2. Modeling of distillation column using process identification techniques
3. Modeling of non isothermal and isothermal reactor using identification techniques
4. Modeling of robotics system for controller design using system identification
5. Modeling of heat exchanger, polymerization process, etc. using system identification

List of Laboratory/Learning Resources Required:

Matlab, Scilab software

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