NATIONAL INSTITUTE OF TECHNOLOGY, TIRUCHIRAPPALLI

DEPARTMENT OF INSTRUMENTATION AND CONTROL ENGINEERING

COURSE PLAN - PART I			
COURSE DETAILS			
Name of the Programme and Specialization	B.Tech. Instrumentation and Control Engineering		
Course Title	System Identification		
Course Code	ICPE26	No. of Credits	3
Course Code of Pre-requisite subject(s)	N. A.	Name of Course Coordinator(s)	N. A.
Course Type	Elective Course	Section	N. A.
Session	January 2023		
Name of Faculty	Dr. Rahul Kumar Sharma		
Department	Instrumentation and Control Engineering		
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SYLLABUS (Approved by BoS)

Introduction, Development of Parameter Estimators, Least-Squares Estimation - Linear Least-Squares, Generalized Least-Squares, Non-Linear Least-Squares, Sufficient Statistics, Analysis of Estimation Errors, MMSE, MAP and ML Estimators, Sequential Least-Squares, Asymptotic properties, General Convergence results.

Introduction to System Identification, Identification based on Differential Equations, Laplace Transforms, Frequency Responses, Difference Equations, Stationarity, Auto-Correlation, Cross-Correlation, Power Spectra, Random and Deterministic Signals for System Identification, Pulse, Step, Pseudo Random Binary Sequence (PRBS), Signal Spectral properties, Persistent Excitation.

Estimates of the Plant Impulse, Step and Frequency Responses from Identification Data, Correlation and Spectral Analysis for Non-Parametric Model Identification, Parametric Models - Equation Error, Output Error Models and Determination of Model Order.

Parametric Estimation using one-step ahead Prediction Error Model Structures and Estimation techniques for ARX, ARMAX, Box Jenkins, FIR, Output Error Models. Residual Analysis for determining Adequacy of the Estimated Models. Recursive System Identification.

Kalman Filtering and other Non-Linear Filters.

Text Books:

1. B. A. Ogunnaike and W. H. Ray, *"Process Dynamics, Modeling, and Control"*, Oxford University Press (1995)
2. A. K. Tangirala, *"Principles of System Identification: Theory and Practice"*, CRC Press (2018)
3. K. J. Keesman, *"System Identification: An Introduction"*, Springer (2011)
4. L. Ljung, *"System Identification: Theory for the User"*, Prentice Hall (1999)
5. Y. Zhu, *"Multivariable System Identification for Process Control"*, Elsevier (2001)
6. T. Söderström and P. Stoica, *"System Identification"*, Prentice Hall (1994)
7. O. Nelles, *"Nonlinear System Identification"*, Springer (2001)

COURSE OBJECTIVES

1. To introduce Empirical and Data-based Modeling of large-scale Systems.
2. To train the Students in Parametric and Non-Parametric Statistical Models and Estimation techniques.
3. To expose to the Students, the Algorithms and Computational overheads involved in large-scale Systems Modeling and Control.

COURSE OUTCOMES (COs)

On completion of this Course, the Students should be able to:

CO1	Conduct Experiments, Design suitable Inputs and generate Data for System Identification.
CO2	Identify the Model Structure and Determine the Order for an unknown Process from Empirical Data.
CO3	Apply Estimation techniques for Parametric and Non-Parametric Models.
CO4	Identify and Validate the Model for practical Process Applications.

MAPPING OF COURSE OUTCOMES (COs) WITH PROGRAMME OUTCOMES (POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	√	√	√	√	√	-	-	-	-	-	-	√	√	√	-
CO2	√	√	√	√	√	-	-	-	-	-	-	√	√	√	-
CO3	√	√	√	√	√	-	-	-	-	-	-	√	√	√	-
CO4	√	√	√	√	√	-	-	-	-	-	-	√	√	√	-

COURSE PLAN - PART II

COURSE OVERVIEW

The course is based on various techniques used for System Identification and Parameter Estimation.

COURSE TEACHING AND LEARNING ACTIVITIES

S. No.	Week / Contact Hours	Topic	Mode of Delivery
1.	1st Week to 3rd Week	Introduction, Development of Parameter Estimators, Least-Squares Estimation - Linear Least-Squares, Generalized Least-Squares, Non-Linear Least-Squares, Sufficient Statistics, Analysis of Estimation Errors, MMSE, MAP and ML Estimators, Sequential Least-Squares, Asymptotic properties, General Convergence results.	Classroom Discussion
2.	4th Week to 6th Week	Introduction to System Identification, Identification based on Differential Equations, Laplace Transforms, Frequency Responses, Difference Equations, Stationarity, Auto-Correlation, Cross-Correlation, Power Spectra, Random and Deterministic Signals for System Identification, Pulse, Step, Pseudo Random Binary Sequence (PRBS), Signal Spectral properties, Persistent Excitation.	Classroom Discussion
3.	7th Week to 9th Week	Estimates of the Plant Impulse, Step and Frequency Responses from Identification Data, Correlation and Spectral Analysis for Non-Parametric Model Identification, Parametric Models - Equation Error, Output Error Models and Determination of Model Order.	Classroom Discussion
4.	10th Week to 12th Week	Parametric Estimation using one-step ahead Prediction Error Model Structures and Estimation techniques for ARX, ARMAX, Box Jenkins, FIR, Output Error Models. Residual Analysis for determining Adequacy of the Estimated Models. Recursive System Identification. Kalman Filtering and other Non-Linear Filters.	Classroom Discussion

COURSE ASSESSMENT METHODS (Ranging from 4 to 6)

S. No.	Mode of Assessment	Week / Date	Duration	% Weightage
1.	Assessment I	5th Week	1 hour	20%
2.	Assessment II	10th Week	1 hour	20%
3.	Assignments	Throughout the Semester		20%
4.	Compensation Assessment	1 Week before Final Assessment	1 hour	20%
5.	Final Assessment	End of the Semester	3 hours	40%

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COURSE EXIT SURVEY (The ways in which the Feedback about the Course will be assessed)

Feedback from Students will be obtained during the Course. The performance of the Students in the tests and their presentation during Classroom Discussion will be used to assess their understanding level.

COURSE POLICY (Including Compensation Assessment to be specified)

- 75% Attendance is must, inclusive of On Duty (OD) or medical grounds. Students not acquiring the required Attendance will be assigned V Grade.
- Relative Grading with Passing minimum of 40% or clustering will be followed on observing the overall performance of the Students at the end of the Semester.
- For the Students missing the Assessments for medical reasons, 1 Compensation Assessment will be conducted 1 Week before the Final Assessment for a weightage equal to that of the missed Assessment. But, Students are advised not to miss the Assessments.
- For Academic Dishonesty, Institute Policy will be followed.

ATTENDANCE POLICY (A uniform Attendance Policy will be followed as specified below)

- At least 75% Attendance is compulsory in each Course.
- A maximum of 10% Attendance will be allowed under On Duty (OD) or medical grounds.

ACADEMIC DISHONESTY AND PLAGIARISM

Institute Policy will be followed. Students are expected to complete all the Assessments on their own; otherwise, zero mark will be awarded to all the Students co-operating one another in this regard.

FOR APPROVAL

Course Faculty	Class Committee Chairperson	Head of the Department
Dr. Rahul Kumar Sharma	Dr. Sri Ram Shankar R.	Dr. K. Dhanalakshmi