NOORUL IASLAM CENTRE FOR HIGHER EDUCATION

NOORUL ISLAM UNIVERSITY

M.E CONTROL AND INSTRUMENTATION ENGINEERING

CURRICULUM & SYLLABUS

SEMESTER – I

Subject Code	Subject	L	T	P	C
MA1501	Advanced Mathematics	3	1	0	4
EI1501	Dynamic Control System	3	0	0	3
EI1502	Digital Signal Processing	3	0	0	3
EI1503	Control System Design	3	0	0	3
EI1504	Advanced Process Control	3	0	0	3
XX5E1	Elective I	3	0	0	3
Practical					
EI1571	Process Control Laboratory	0	1	2	2
Total 20 Credits		18	2	2	21

MA1501 **ADVANCED MATHEMATICS**

L	T	P	C
3	1	0	4

AIM:

To gain a well found knowledge of optimizing a function and variational problems which provide necessary mathematical support and confidence to tackle real life problems.

OBJECTIVE:

The course objective is to extend the ability of the students in the areas of Matrix Theory and Stochastic Processes. This will be applicable in Engineering practices and serve as a pre-requisite for higher studies and research.

UNIT I ADVANCED MATRIX THEORY **9**

Generalised Eigen vectors– Jordan canonical form — Matrix norms – Singular value decomposition – Pseudo inverse – Least square approximations – QR algorithm.

UNIT II SPECIAL FUNCTIONS **9**

Bessel's equation – Bessel function – Recurrence relations - Generating function and orthogonal property for Bessel functions of first kind – Fourier-Bessel expansion.

UNIT III RANDOM PROCESSES **9**

Classification – Stationary random processes – Ergodic process - Auto correlation – Cross correlations – Properties - Power spectral density.

UNIT IV DYNAMIC PROGRAMMING **9**

Bellman's principle of optimality – Characteristics of the dynamic programming model – The recursive equation approach – Solution of discrete dynamic programming problem.

UNIT V CALCULUS OF VARIATIONS **9**

Euler's equation – Functional dependent on first and higher order derivatives – Functional dependent on functions of several independent variables -Isoperimetric Problems.

L: 45 + T: 15, TOTAL: 60 PERIODS

REFERENCES:

1. Bronson, R., "Matrix Operations", Schaum's Outline Series, McGraw–Hill, New York
2. Gupta, A.S., "Calculus of Variations with Applications", Prentice-Hall of India, New Delhi.
3. Dr.Venkataraman, M.K., " Higher Mathematics for Engineering and Science", National Publishing Company.1992.
4. Taha, H.A., "Operations Research – An Introduction", Sixth Edition, Prentice-Hall of India, New Delhi.
5. Gupta, P.K. and Hira, D.S., "Operations Research", S.Chand & Co. New Delhi.
6. Peebles Jr., P.Z., "Probability, Random Variables and Random Signal Principles", McGraw-Hill Inc..

EI1501 DYNAMIC CONTROL SYSTEM 3 0 0 3

AIM

To gain knowledge in analysis of non-linear system and digital control of linear system.

OBJECTIVES

i. To study the description and stability of non-linear system.
ii. To study the conventional technique of non-linear system analysis.
iii. To study the analysis discrete time systems using conventional techniques.
iv. To study the analysis of digital control system using state-space formulation.
v. To study the formulation and analysis of multi input multi output (MIMO) system

1. PHYSICAL SYSTEMS AND STATE ASSIGNMENT 9

Electrical Systems - Mechanical Systems – Hydraulic Systems – Pneumatic Systems – Thermal systems –Modelling of some typical systems like DC Machines - Inverted Pendulum.

2. STATE SPACE ANALYSIS 9

Realisation of State models: – Non-uniqueness - Minimal realization – Balanced realization – Solution of state equations: – State transition matrix and its properties - Properties: Controllability and observability- Stabilisability and detectability – Kalman decomposition.

3. MIMO SYSTEMS –FREQUENCY DOMAIN DESCRIPTIONS 9

Properties of transfer functions – Impulse response matrices – Poles and zeros of transfer function matrices – Critical frequencies – Resonance – Steady state and dynamic response – Bandwidth- Nyquist plots-Singular value analysis.

4. NON-LINEAR SYSTEMS 9

Types of non-linearity – Typical examples – Equivalent linearization - Phase plane analysis – Limit cycles – Describing functions- Analysis using Describing functions- Jump resonance.

5. STABILITY 9

Stability concepts – Equilibrium points – BIBO and asymptotic stability – Direct method of Liapunov – Application to non-linear problems – Frequency domain stability criteria – Popov’s method and its extensions.

TOTAL = 45 PERIODS

REFERENCES

1. M.Gopal, “Modern Control Engineering”, Wiley, 1996.
2. J.S. Bay, “Linear State Space Systems”, McGraw-Hill, 1999.
3. Eroni-Umez and Eroni, “System dynamics & Control”, Thomson Brooks/ Cole, 1998.
4. K.Ogatta, “Modern Control Engineering”, Pearson Education Asia, Low Priced Edition, 1997.
5. G.J.Thaler, “Automatic Control Systems”, Jaico publishers, 1993.
6. A. Nagoorkani, “Advanced Control Theory”, RBA publications, 1999.

EI1502 DIGITAL SIGNAL PROCESSING 3 0 0 3

Prerequisite: Signals and Systems

AIM

To introduce the concept of analyzing discrete time signals & systems in the time and frequency domain.

OBJECTIVES

I. To classify signals and systems & their mathematical representation.
II. To analyse the discrete time systems.
III. To study various transformation techniques & their computation.
IV. To study about filters and their design for digital implementation.
V. To study about a programmable digital signal processor & quantization effects.

1. DISCRETE TIME SIGNALS AND SYSTEMS 9

Representation of discrete time signal – classifications – Discrete time – system – Basic operations on sequence – linear – Time invariant – causal – stable – solution to difference equation – convolution sum – correlation – Discrete time Fourier series – Discrete time Fourier transform.

2. FOURIER AND STRUCTURE REALIZATION 9

Discrete Fourier transform – properties – Fast Fourier transform – Z-transform - properties – structure realization – Introduction to IIR and FIR Structures- Direct form – lattice structure for FIR filter – Lattice structure for IIR Filter.

3.FILTERS 9

FIR Filter – windowing technique – optimum equiripple linear phase FIR filter – IIR filter – Bilinear transformation technique – impulse invariance method – Butterworth filter – Tchebyshev filter.

4.MULTISTAGE REPRESENTATION 9

Sampling of band pass signal – antialiasing filter – Decimation by a n integer factor – interpolation by an integer factor – sampling rate conversion – implementation of digital filter banks – sub-band coding – Quadrature mirror filter – A/D conversion – Quantization – coding – D/A conversion – Introduction to wavelets.

5.DIGITAL SIGNAL PROCESSORS 9

Introduction – Architecture – Features – Addressing Formats – Functional modes
Commercial Processors-CS48520/40/60 Cirus DSP processor-SHARC PROCESSOR ARCHITECTURE ADSP-214XX-Texas instruments C674x Low Power DSP chips

TOTAL = 45 PERIODS

REFERENCES

1. John G.Proakis, Dimitris G.Manolakis, “Digital Signal Processing: Principles,

Algorithms and Applications", PHI.
2. S.Salivahanan, A.Vallavaraj and C.Gnanapriya "Digital Signal Processing, TMH, 2000.
3. A.V. Oppenheim and R.W.Schafer, Englewood "Digital Signal Processing", Prentice-Hall, Inc, 1975.
3. The Scientist and Engineer's Guide to Digital Signal Processing By Steven W. Smith, Ph.D.
4. B.Venkatramani & M.Bhaskar, "Digital Signal Processors architecture, programming and applications", TMH, 2002.

EI1503 CONTROL SYSTEM DESIGN 3 0 0 3

AIM

To provide sound knowledge in the basic concepts of linear control theory and design of control system.

OBJECTIVES

- i. To understand the performance of system and controllers
- ii. To provide adequate knowledge in state variable design
- iii. To understand the concept of robustness and the adequate case studies

1. INTRODUCTION TO DESIGN AND CLASSICAL PID CONTROL 9

Systems performance and specifications –Proportional, Integral and Derivative Controllers – Structure – Empirical tuning- Zeigler Nichols-Cohen Coon – Root Locus method – Open loop inversion- affine parameterisation – Tuning using ISE, IAE and other performance indices.

2. STATE VARIABLE DESIGN 9

Design by state feedback – Output feedback – Pole assignment technique – Design of state and output feedback controllers – Design of reduced and full order observers – PI feedback – Dynamic state feedback.

3. OPTIMAL CONTROLLER DESIGN 9

Statement of optimal control problem – Solution of optimal control problems using variational approach – Solution of optimal control problems using Ricatti equation –Infinite time problems -Solution

4. ROBUST CONTROL SYSTEMS 9

H_∞ and H norms .– System Sensitivity – Analysis of Robustness – Systems with uncertain Parameters – Design of Robust Control Systems –Control synthesis –loop shaping techniques

5. CASE STUDIES 9

Optimal Aircraft control – Optimal Control of Fuel- Optimal Air ratio in automotive engine – Optimal Control of Hard Disk Drive – Optimal Control of CSTR process – Optimal Control of pH process

TOTAL = 45 PERIODS

REFERENCES

1. G. C. Goodwin and etal, “Control system design’, Pearson Education, 2003.
2. G. F. Franklin and etal, “ Feedback Control of Dynamic Systems”, Pearson Education systems, 2002.
3. Nagrath I J and Gopal M, “Control Systems Engineering”, New Age International Publishers, Fifth Edition, 2008.
4. Kemin Zhou and John Doyle, “Essentials of Robust Control”, Prentice-Hall Inc., 1998.
5. W. J. Granttham, T.L. Vincent, “ Modern Control Systems Analysis and Design, John Wiley & Sons, 1993.
6. Gopal M, “Control Systems Principles and Design”, Tata McGraw Hill Publishing Company Limited, Eighth Edition, 2008.

EI1504 ADVANCED PROCESS CONTROL 3 0 0 3

AIM

To provide the in depth knowledge of controllers, find control elements and the processes.

OBJECTIVES

i. To study the basic characteristics of first order and higher order processes.
ii. To get adequate knowledge about the characteristics of various controller modes and methods of tuning of controller.
iii. To study about various complex control schemes.
iv. To study about the construction, characteristics and application of control valves.
v. To study the five selected unit operations and a case study of distillation column control.

1. PROCESS DYNAMICS 9

Introduction to process control-objective of modelling-models of industrial process-hydraulic tanks-fluid flow systems-mixing process-chemical reactions-thermal systems-heat exchangers and distillation column.

2. CONTROL ACTIONS AND CONTROLLER TUNING 9

Characteristic of ON-OFF, P, P+I, P+D and P+I+D control modes – Electronic PID controller –Digital PID algorithm – Auto/manual transfer - Reset windup – Practical forms of PID Controller - Pneumatic and electric actuators – Valve Positioner – Control Valves – Characteristic of Control Valves:- Inherent and Installed characteristics

3. COMPLEX CONTROL TECHNIQUES 9

Feed forward control technique-ratio control technique -cascade control technique -split range control technique -inferential control technique -predictive control technique -adaptive and multivariable control technique

4.MODEL BASED CONTROLLERS 9

Single Varible Model Predictive Control- Introduction - Predictive Control structure-Internal Model Controller -Smith Predictor-Implementation Guidelines-Algorithm Selection Guidelines

5. INDUSTRIAL PROCESS CONTROL 9

Basic building blocks of computer control system – Interfaces –Serial, Parallel and USB Communication-Data acquisition systems – SCADA – Direct digital control
Evolution of PLC – Sequential and Programmable controllers –. Evolution of DCS – DCS Architecture

TOTAL = 45 PERIODS

REFERENCES

1. George Stephanopolus, "Chemical Process Control", Prentice Hall India
2. Harriot P., “Process Control”, Tata McGraw-Hill, New Delhi, 1991.
3. Norman A Anderson,” Instrumentation for Process Measurement and Control” CRC Press LLC, Florida, 1998.
4. Thomas E.Marlin “Process Control”, Second Edition McGraw hill, New York, 2000
5. Marlin T.E., “Process Control”, Second Edition McGraw hill, New York, 2000.
6. Balchan J.G. and Mumme G., “Process Control Structures and Applications”, Van Nostrand Renhold Co., New York,1988.
7. Lucas M.P, “Distributed Control System”, Van Nostrand Reinhold Co. NY 1986
8. Pertrezeulla, “Programmable Controllers”, McGraw-Hill, 1989

EI1571 PROCESS CONTROL LABORATORY 0 1 2 2

AIM

To experimentally verify the process control concepts on the selected process control loops.

1. Operation of interacting and non-interacting systems
2. Responses of different order processes with and without transportation lag
3. Response of on-off controller
4. Response of P+I+D controller
5. Characteristics of control valve with and without positioner
6. Operation of on-off controlled thermal process
7. Closed loop response of flow control loop
8. Closed loop response of level control loop

9. Closed loop response of temperature control loop
10. Closed loop response of pressure control loop
11. Tuning of controllers
12. Study of complex control system (ratio / cascade / feed forward)

TOTAL = 45 PERIODS

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M. E. CONTROL AND INSTRUMENTATION ENGINEERING

CURRICULUM & SYLLABUS

SEMESTER II

Subject Code	**Subject**	**L**	**T**	**P**	**C**
EI1505	Industrial Data Communication	3	0	0	3
EI1506	Digital Control System	3	0	0	3
EI1507	Process Instrument Design	3	0	0	3
EI1508	Industrial Instrumentaion	3	0	0	3
EI1509	Intelligent Control Techniques	3	0	0	3
XX15E2	Elective II	3	0	0	3
Practical					
EI1572	Instrumentation System Design Laboratory	0	1	2	2
Total: 20 Credits		18	1	2	20

EI1505 INDUSTRIAL DATA COMMUNICATION 3 0 0 3

AIM

1. To provide comprehensive knowledge of analog to digital conversion and data acquisition
2. To explain pc based instrumentation systems.

OBJECTIVES

i. To provide fundamental knowledge about various analog to digital conversion methods.
ii. To provide comprehensive knowledge about data acquisition.
iii. To give basic knowledge in the architecture and interfacing using microprocessors
iv. To understand source digitization, digital multiplexing and modulation.
v. To give basic knowledge about HART (Highway Addressable Remote Transducer) and field bus technology

1. BASIC BLOCKS 9

Overview of A/D converter, types and characteristics-Understanding Data acquisition, A/D and S/H terms-passive support and Active support components-Single and Multi-slope, Low cost A/D conversion techniques, types-Electromechanical A/D converter.

2. DATA ACQUISITION SYSTEMS 9

Objective - Building blocks of Automation systems – Multi channel Data Acquisition system-Single channel Data Acquisition systems- PC based Data Acquisition systems, Data loggers-Sensors based computer data systems.

3. INTERFACING AND DATA TRANSMISSION 9

Data transmission systems- 8086 Microprocessor based system design - Peripheral Interfaces – Time Division Multiplexing (TDM) – Digital Modulation – Pulse Modulation – Pulse Code Format – Interface systems and standards – Communications.

4. PC BASED INSTRUMENTATION 9

Introduction - Evolution of signal Standard - HART Communication protocol - Communication modes - HART networks - control system interface - HART commands - HART field controller implementation - HART and the OSI model - Field bus –Introduction - General field bus architecture - Basic requirements of field bus standard -field bus topology - Interoperability – interchangeability - Instrumentation buses-Mod bus - GPIB - Network buses – Ethernet - TCP/IP protocols

5. CASE STUDIES 9

PC based industrial process measurements for flow- PC based industrial process measurements for temperature- PC based industrial process measurements for pressure and level – PC based instruments development system.

TOTAL = 45 PERIODS

REFERENCES

1. Kevin M. Daugherty, “Analog – to – Digital conversion – A Practical Approach”, McGraw Hill International Editions, 1995
2. N. Mathivanan, “Microprocessors, PC Hardware and Interfacing”, Prentice – Hall of India Pvt. Ltd., 2003.
3. Krishna Kant “Computer- based Industrial Control” ,Prentice- Hall of India Pvt. Ltd., 1997
4. H S. Kalsi, “Electronic Instrumentation”, Technical Education Series (TES)/TMH, New Delhi.
5. Buchanan., “Computer busses”, Arnold,London,2000.

EI1506 DIGITAL CONTROL SYSTEM 3 0 0 3

AIM

To gain knowledge in analysis of non-linear system and digital control of linear system.

OBJECTIVES

i. To study the description and stability of non-linear system.
ii. To study the conventional technique of non-linear system analysis.
iii. To study the analysis discrete time systems using conventional techniques.
iv. To study the analysis of digital control system using state-space formulation.
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1. INTRODUCTION 9

Sampling and holding – Sample and hold devices – D/A and A/D conversion – Reconstruction – Z transform – Inverse Z transform – Properties – Pulse transfer function and state variable approach – Review of controllability, observability.

2. DESIGN USING TRANSFORM TECHNIQUES 9

Methods of discretisation – Comparison –Frequency response methods – Root locus method, Controller design using root locus, Nyquist stability criteria, Bode plot, Lead compensator design using Bode plot, Lag compensator design using Bode plot, Lag-lead compensator design in frequency domain

3. QUANTIZATION EFFECTS AND SAMPLE RATE SELECTION 9

Analysis of round off error – Parameter round off – Limit cycles and dither – Sampling theorem limit – Time response and smoothness – Sensitivity to parameter variations – Measurement noise and antialising filter – Multirate sampling

4. DESIGN USING STATE SPACE TECHNIQUES 9

State space design – Introduction to state variable model, Various canonical forms, Characteristic equation, state transition matrix, Solution to discrete state equation- Pole assignment - Design of state feedback controller through pole placement – Necessary and sufficient conditions, Ackerman’s formula-State Observers - Optimal control – State estimation in the presence of noise –Kalman filter– Effect of delays.

5. COMPUTER BASED CONTROL **9**

Selection of processors – Mechanization of control algorithms – PID control laws – Digital Temperature Control System- Application to temperature control and Control Algorithm– Control of electric drives – Data communication for control-Field buses

TOTAL = 45 PERIODS

REFERENCES

1. Gopal.M., “Digital control Engineering “, Wiley Eastern Ltd.,1989.
3. G.F.Franklin, J.David Powell, Michael Workman, “Digital control of Dynamic Systems”, 3rd Edition, Addison Wesley, 2000.
4. M.Gopal, ‘Digital Control and State Variables Methods’, Tata McGraw HILL, 2nd Edition, 2003.
5. Paul Katz, “Digital control using Microprocessors”, Prentice Hall, 1981.
6. Forsytheand.W.Goodall.R.N., “Digital Control”, McMillan,1991.
7. Chesmond, Wilson, Lepla, “Advanced Control System Technology”, Viva – low price edition, 1998.

EI1507 **PROCESS INSTRUMENT DESIGN** **3 0 0 3**

AIM

To gain knowledge in the designing of process instruments.

OBJECTIVES

i. To design signal conditioning circuits.
ii. To design transmitters and controllers.
iii. To design final control elements.

1.DESIGN OF SIGNAL CONDITIONING CIRCUITS **9**

Design of V/I Converter and I/V Converter- Analog and Digital Filter design – Signal conditioning circuit for pH measurement –Compensation circuit - Signal conditioning circuit for Temperature measurement - Cold Junction Compensation – software and Hardware approaches -Thermocouple Linearization – Software and Hardware approaches

2.DESIGN OF TRANSMITTERS **9**

RTD based Temperature Transmitter – Thermocouple based Temperature Transmitter-Design of Capacitance based Level Transmitter – Air-purge Level Measurement – Design of Smart Flow Transmitters.

3.DESIGN OF DATA LOGGER AND PID CONTROLLER **9**

Design of ON / OFF Controller using Linear Integrated Circuits- Electronic PID Controller – Microcontroller Based Digital PID Controller - Micro - controller based Data Logger – Design of PC based Data Acquisition Cards

4.ORIFICE AND CONTROL VALVE SIZING **9**

Orifice Sizing: - Liquid, Gas and steam services - Control Valves – Valve body:- Commercial valve bodies – Control valve sizing – Liquid, Gas and steam Services – Cavitation and flashing –Selection criteria – Rotameter Design.

5.DESIGN OF ALARM AND ANNUNCIATION CIRCUIT **9**

Alarm and Annunciation circuits using Analog Circuits – and Alarm and Annunciation circuits using Digital Circuits Thyristor Power Controller – Design usig Programmable Logic Controller

TOTAL = 45 PERIODS

REFERENCES

1. C. D. Johnson, "Process Control Instrumentation Technology", 8th Edition, Prentice Hall, 2006.
2. Control Valve Handbook, 4th Edition, Emerson Process Management, Fisher Controls International, 2005.
3. R.W. Miller, "Flow Measurement Engineering Handbook", Mc-Graw Hill, NewYork1996.

EI1508 INDUSTRIAL INSTRUMENTATION 3 0 0 3

AIM

To equip the students with relevant knowledge to suit the industrial requirement.

OBJECTIVES

i. To study about humidity,moisture and pressure measurements.
ii. To study about mechanical flow meters and their installation.
iii. To know about various types of level measurements adopted in industry environment.
iv. To study about various temperature measurements.

UNIT I **9**

Measurement of Pressure: Fluid properties relating to pressure measurement- manometer - Bourdon gauge- diaphragm gauge - bellows gauge- bell gauge-electrical types - vacuum gauge- Mcleod gauge- Pirani gauge - ionization gauge - thermocouple gauge - pressure transducers and pressure transmitters- differential pressure measurement -instrument calibration principles -instrument mounting , IC Pressure sensor .

UNIT II **9**

Measurement of Flow: Variable head and variable area type flow meters: Orifice plate, Venturi tube, Dahl tube, Flow nozzle, Pitot tube-Rota meter-positive displacement meterturbine flow meter- electromagnetic flow meter-mass flow meter - ultrasonic flow meter-solid flow measurement-calibration of flow meters.

UNIT III **9**

Measurement of Level:Displacer and torque tube - bubbler tube - D/P methods - hydrostatic head level measurement - electrical methods: resistance, capacitance type, nucleonic and ultrasonic type level gauges, solid level measurement.

UNIT IV **9**

Measurement of Temperature: Resistance thermometer, 3-lead and 4-lead arrangement-thermistor-thermocouple types and ranges-cold junction compensation-linearization of thermocouple-radiation pyrometer- optical pyrometers.

UNIT V **9**

Measurement of weight, density, and vibration: Load cell method- strain gauge, LVDT, Piezo electric pneumatic and hydraulic load cell- null balance method-conveyer belt weighing for online measurement- Constant volume hydrometer – gamma ray density measurement-vibrating probe liquid densitometer.

TOTAL = 45 PERIODS

REFERENCES:

1. D. Patranabis, Principles of Industrial Instrumentation, Tata MCGraw Hill, 1998.
2. Donald P.Eckman, Industrial Instrumentation, Wiley Eastern Limited, 1991.
3. R.Donald Gillum, Industrial Pressure Measurement, ISA, 1982.
4. R.Donald Gillum, Industrial Level Measurement, ISA, 1984.
5. David W.Spitzer, Industrial Flow Measurement, ISA, 1990
6. John P.Bentely, Principles of Measurement System, Longman Scientific and Technical,1995
7. Jone's, Instrument Technology, Vol. 1: Mechanical Measurements, English Language Book Society, Fourth Edition, 1985
8. Douglas M.Considine,Editor-in-Chief, Process Instruments and Controls Handbook, Fourth Edition, McGraw-Hill Book Co., 1994
9. Doebelin, E.O., Measurement Systems, McGraw Hill, Fourth edition, Singapore,1990.
10. R.K. Jain, Mechanical and Industrial measurements, Khanna publishers, Delhi, 1990

EI1509 INTELLIGENT CONTROL TECHNIQUES 3 0 0 3

AIM

To present the concepts of intelligent agents, searching, knowledge and reasoning, planning, learning and expert systems.

OBJECTIVES

i. To study the idea of intelligent agents and search methods.
ii. To study about representing knowledge.
iii. To study the reasoning and decision making in uncertain world.
iv. To construct plans and methods for generating knowledge.
v. To study the concepts of expert systems

1. INTRODUCTION 9

Approaches to intelligent control-Architecture for intelligent control- Symbolic reasoning system-rule-based systems- the Artificial Intelligent approach. Knowledge representation-Expert systems.

2.ARTIFICIAL NEURAL NETWORKS 9

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and Training the neural network, Hopfield network, Self-organizing network and Recurrent network, Neural Network based controller

3. GENETIC ALGORITHM 9

Basic concept of Genetic algorithm and detail algorithmic steps- Flow Chart- adjustment of free parameters, Solution of typical control problems using genetic algorithm.-optimization of process parameters using genetic algorithm.

4. FUZZY LOGIC SYSTEM 9

Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning, Introduction to fuzzy logic modeling and control, Fuzzification, inferencing and defuzzification, Fuzzy knowledge and rule bases, Fuzzy modeling and control schemes for nonlinear systems.

5. APPLICATIONS 9

Design of controllers using Neural Networks, Fuzzy Logic and Genetic algorithm for Inverted Pendulum system - Fuzzy Logic and Genetic algorithm for Heat Exchanger process.

TOTAL = 45 PERIODS

REFERENCES

1. Jacek.M.Zurada, "Introduction to Artificial Neural Systems", Jaico Publishing House, 1999.
2. KOSKO,B. "Neural Networks And Fuzzy Systems", Prentice-Hall of India Pvt. Ltd., 1994.
3. KLIR G.J. & FOLGER T.A. "Fuzzy sets, uncertainty and Information", Prentice-Hall of India Pvt. Ltd., 1993.
4. Zimmerman H.J. "Fuzzy set theory-and its Applications"-Kluwer Academic Publishers, 1994.
5. Driankov, Hellendroon, "Introduction to Fuzzy Control", Narosa Publishers.

EI1572 INSTRUMENTATION SYSTEM DESIGN LABORATORY 0 1 2 2

AIM

This purpose of this lab is to impart an adequate knowledge and expertise the design of filters, amplifiers, converters, transmitters and signal conditioning circuits and instrumentation documentation preparation

OBJECTIVE

The knowledge gained by the student in this area will be of immerse help and ease for him in instrumentation system design.

1. Design and implementation of instrumentation amplifier.
2. Design and implementation of active filter.
3. Design and implementation of V/I and I/V converters.
4. Design and implementation of cold – junction compensation circuit for thermocouple.
5. Design and implementation of signal conditioning circuit for RTD.
6. Design of orifice plate and rotameter.
7. Design of control valve (sizing and flow – lift characteristic)
8. Design of PID controller (using operational amplifier and microprocessor)
9. Piping and Instrumentation Diagram – case study.
10. Preparation of documentation of instrumentation project (process flow sheet, instrument index sheet and instrument specifications sheet).

TOTAL = 45 PERIODS

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M.E. CONTROL AND INSTRUMENTATION ENGINEERING

CURRICULUM & SYLLABUS

SEMESTER - III

Subject Code	**Subject**	**L**	**T**	**P**	**C**
THEORY					
xx5xx	Elective III	3	0	0	3
xx5xx	Elective IV	3	0	0	3
xx5xx	Elective V	3	0	0	3
PRACTICAL					
EI1573	Control & Instrumentation Laboratory	0	1	2	2
EI15P1	Project Work Phase I	0	0	12	6
TOTAL		9	1	14	17

EI1573 CONTROL & INSTRUMENTATION LABORATORY 0 1 2 2

LIST OF EXPERIMENTS

1. Study of MATLAB, LABVIEW and MATHCAD on control applications.
2. Study of Data Loggers / Data Acquisition Systems.
3. Experimental modelling of Transducers
4. Simulation of Electric drives with P, PI and PID controllers using MATLAB / MATHCAD
5. Interfacing PC with Real-time systems.
6. Digital position control system.
7. Digital control of second-order plan using Micro controllers.
8. Digital temperature and level control.
9. Design and analysis of second-order filters.
10. Design of DSP based controllers.
11. Design of Intelligent controllers for physical systems.
12. Design of Programmable Logic Controllers for real-time systems.

TOTAL: 45 PERIODS

NOORUL ISLAM CENTRE FOR HIGHER EDUCATION

NOORUL ISLAM UNIVERSITY, KUMARACOIL

M.E. CONTROL AND INSTRUMENTATION ENGINEERING

CURRICULUM & SYLLABUS

SEMESTER – IV

Subject Code	Subject	L	T	P	C
EI15P5	Project Work Phase II	0	0	36	18
TOTAL		0	0	36	18

NOORUL ISLAM CENTRE FOR HIGHER EDUCATION

NOORUL ISLAM UNIVERSITY, KUMARACOIL

M.E. CONTROL AND INSTRUMENTATION ENGINEERING

CURRICULUM & SYLLABUS

LIST OF ELECTIVES

SI. No.	Subject Code	Subject	L	T	P	C
1	EI15A1	Applied Bio-Medical Instrumentation	3	0	0	3
2	EI15A2	System Identification and Adaptive Control	3	0	0	3
3	EI15A3	Advanced Topics in Instrumentation Systems	3	0	0	3
4	EI15A4	Computer Aided Analysis And Design of Systems	3	0	0	3
5	EI15A5	Piping and Instrumentation Design	3	0	0	3
6	EI15A6	Robotics and Automation	3	0	0	3
7	EI15A7	Optimal Control and Filtering	3	0	0	3
8	EI15A8	Embedded Control System Design	3	0	0	3
9	EI15A9	Micro and Nano Electro Mechanical System	3	0	0	3
10	EI15B1	Process Modelling & Simulation	3	0	0	3

EI15A1 APPLIED BIO-MEDICAL INSTRUMENTATION 3 0 0 3

Prerequisite: None

AIM

The course is designed to make the student acquire an adequate knowledge of the physiological systems of the human body and relate them to the parameters that have clinical importance. The fundamental principles of equipment that are actually in use at the present day are introduced.

OBJECTIVES

- To provide an acquaintance of the physiology of the heart, lung, blood circulation and circulation respiration. Methods of different transducers used.
- To introduce the student to the various sensing and measurement devices of electrical origin.
- To provide the latest ideas on devices of non-electrical devices.
- To bring out the important and modern methods of imaging techniques.

To provide latest knowledge of medical assistance / techniques and therapeutic equipments.

1. INTRODUCTION TO BIOMEDICAL MEASUREMENTS 9

Physiological systems and measurable variables- Nature and complexities of biomedical measurements- Medical equipment standards- organization, classification and regulation- Biocompatibility - Human and Equipment safety – Physiological effects of electricity, Micro and macro shocks, thermal effects.

2 .ADVANCES IN MODELING AND SIMULATIONS IN BIOMEDICAL INSTRUMENTATION 9

Modeling and simulation in Biomedical instrumentation – Difference in modeling engineering systems and physiological systems – Model based analysis of Action Potentials - cardiac output – respiratory mechanism - Blood glucose regulation and neuromuscular function.

3. BIOMEDICAL SIGNALS AND THEIR ACQUISITIONS 9

Types and Classification of biological signals – Signal transactions – Noise and artifacts and their management - Biopotential electrodes- types and characteristics - Origin, recording schemes and analysis of biomedical signals with typical examples of Electrocardiography(ECG), Electroencephalograhy(EEG), and Electromyography (EMG)– Processing and transformation of signals-applications of wavelet transforms in signal compression and denoising.

4. INSTRUMENTATION FOR DIAGNOSIS AND MONITORING 9

Advanced medical imaging techniques and modalities -Instrumentation and applications in monitoring and diagnosis- Computed tomography, Magnetic Resonance

Imaging and ultrasound- Algorithms and applications of artificial intelligence in medical image analysis and diagnosis-Telemedicine and its applications in telemonitoring.

5. BIOMEDICAL IMPLANTS AND MICROSYSTEMS 9

Implantable medical devices: artificial valves, vascular grafts and artificial joints- cochlear implants - cardiac pacemakers – Microfabriation technologies for biomedical Microsystems- microsensors for clinical applications – biomedical microfluid systems

TOTAL: 45 PERIODS

REFERENCES:

1. John G.Webster (editor), Bioinstrumentation, John Wiley & Sons, 2004.
2. Shayne Cox Gad, Safety Evaluation of Medical Devices, Marcel Deckle Inc, 2002.
3. Michael C. K. Khoo, Physiological Control Systems- Analysis Simulation and Estimation, 2001.
4. John G.Webster (editor), Medical Instrumentation Application and design, John Wiley & Sons, 2005.
5. Cromwell l., Biomedical Instrumentation and Measurements, Prentice Hall of India, 1995.
6. Rangaraj M.Rangayan, Biomedical signal analysis, John Wiley & Sons (ASIA) Pvt. Ltd.,
7. Kayvan najarian and Robert splinter, Biomedical Signal and Image Processing, CRC Press, 2005.
8. John M.Semmlow, Biosignal and Bio medical Image processing, CRC Press, 2004.
9. Joseph J. Carr and John M Brown, Introduction to Biomedical Equipment Technology, Pearson Education, 2004
10. Strong P, Biophysical measurements, Tektronix Inc 1997

EI15A2 SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL 3 0 0 3

Prerequisite: Control System

AIM

To gain knowledge on adaptive control of systems through parameter identification and controller retuning.

OBJECTIVES

- To study the definition of adaptive control and methods of adaptation.
- To study the parameter identification of systems.
- To study the self-tuning of PID controllers based on parameter identification.
- To study the model reference adaptive control.

To study the practical application through case studies.

1. SYSTEMS AND MODELS 9

Models of LTI systems: Linear Models-State space Models, Model sets, Structures and Identifiability-Models for Time-varying and Non-linear systems: Models with

Nonlinearities – Non-linear state-space models-Black box models, Fuzzy models, Model approximation and validation-Random Process Modelling.

2.PARAMETRIC AND NON-PARAMETRIC ESTIMATION METHODS 9

Transient response and Correlation Analysis – Frequency response analysis – Spectral Analysis – Least Square – Recursive Least Square –Maximum Likelihood – Instrumental Variable methods – Pseudo Linear Regression

3.LINEAR AND NON-LINEAR ESTIMATION TECHNIQUES 9

Open and Closed loop identification: Approaches – Direct and indirect identification – Joint input-output identification – Non-linear system identification – Wiener models – Power series expansions - Multidimensional Identification – State estimation techniques – FFT based, Model based Spectral estimation techniques.

4.CLASSIFICATION OF ADAPTIVE CONTROL 9

Introduction – Uses – Auto tuning – Self Tuning Regulators (STR) – Model Reference Adaptive Control (MRAC) – Types of STR and MRAC – Different approaches to self-tuning regulators – Stochastic Adaptive control – Gain Scheduling.

5. APPLICATIONS OF ADAPTIVE CONTROL 9

Recent trends in self tuning – Recent trends in Stability, Recent trends in Convergence and Robustness studies - Model Updating – General purpose Adaptive regulator – Applications to process control.

TOTAL = 45 PERIODS

REFERENCES

1. Ljung,” System Identification Theory for the User”, PHI, 1987.
2. Rolf Johansson,” System Modelling and Identification”, Prentice Hall of India,
3. Astrom and Wittenmark,” Adaptive Control ”, PHI
1. William S. Levine, “ Control Hand Book”.
2. Narendra and Annasamy,” Stable Adaptive Control Systems, Prentice Hall, 1989.

EI15A3 ADVANCED TOPICS IN INSTRUMENTATION SYSTEMS 3 0 0 3

Prerequisite: Sensors and Transducers

1. FIBRE AND LASER OPTIC INSTRUMENTATION 9

Fiber optics sensors - fiber optic instrumentation system -Different types of modulators – detectors - Interferometer method of measurement of length - Moire fringes - measurement of pressure, temperature, level and strain – Introduction to LASER- Laser for measurement of distance, length, velocity and acceleration - material processing - laser heating and welding - removal and vaporization.

2. MICROPROCESSOR BASED INSTRUMENTATION 9

Hardware and firmware components of a microprocessor system - micro controllers - multiple processors - An example application of a microprocessor system -calibration and correction - human interface - computer interface - software characteristics of the computer interface - numerical issues - Embedded programming issues.

3. SMART INSTRUMENTS 9

Smart/intelligent transducer-comparison with conventional transducers-self diagnosis and remote Calibration features-Smart transmitter with HART communicator-Measurement of strain, flow, and pH with smart transmitters.

4. VIRTUAL INSTRUMENTATION 9

Block diagram and architecture of the virtual instrumentation - VIs and sub VIs, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, string and file I/O.

5. INTRODUCTION TO MEMS 9

Overview of MEMS – History of MEMS – Scaling laws in miniaturization - Materials for MEMS – Micro system design and Fabrication process – Micro sensor – Micro Actuators.

TOTAL = 45 PERIODS

REFERENCES

1. Chapman,P., “Smart Sensors”, ISA Publications,1995.
2. John F Ready, “Industrial Applications of Lasers”, Academic press,1978.
3. Jasprit Singh, “Semiconductor Optoelectronics”, McGraw Hill, 1995.
4. F.Coombs, jr, Electronic instrument handbook Clyde. second edition
5. Lisa K.Wells & Jeffrey Travels, ‘ Labview for every one”, Prentice Hall, 1997
6. Sokoloff, “Basic concepts of Labview 4”, Prentice Hall 1998.
7. Tai Ran Hsu, “MEMS and Micro System Design and Manufacture”, Tata McGraw Hill, 2002.

EI15A4 COMPUTER AIDED ANALYSIS AND DESIGN OF SYSTEMS 3 0 0 3

1. ALGORITHM SOLVING 9

Linear and Non linear equation – solution – computation algorithm Methods , Runge-Kutta,Eulers method— realization – simulation – properties, Stability analysis, Mat lab for developing Bode – Nyquist – polar plots optimisation – controller design – system performance evaluation

2. MATHEMATICAL MODEL OF PHYSICAL SYSTEMS 9

Transfer function (Tf) and state space (SS) model analysis .Derivation of mathematical model for electrical, mechanical, hydraulic, thermal and pneumatic systems. Simulation of open loop response of first order, second order, and FODT process for various test inputs in

MATLAB. Conversion of transfer function to state space and state space to Transfer function

3. CONTROLLER DESIGN **9**

Design of controllers – , Design of conventional PID controller,Tunning methods, CC and ZN methods Fuzzy, Neural and neuro fuzzy controller design for electrical, mechanical, hydraulic, thermal and pneumatic systems-Matlab simulation in SIMULINK

4. CLOSED LOOP OPERATION **9**

Concept of open loop and close loop systems - Design of controllers – Controller Dynamics -sensor dynamics – noise generation – Filter Design - actuator dynamics- closed loop simulation using MATLAB platform.

5. SYMBOLIC PROGRAMMING **9**

Introduction- Symbolic programming – programming constructs – data structure – computation with formulae - data structure – computation procedures – numerical programming

TOTAL = 45 PERIODS

REFERENCES

1. Chen, "System and signal analysis", second edition , oxford university press, 1994.
2. K. Ogatta ," Modern control Engineering ", Fourth edition ,Pearson education 2002
3. Dorf and Bishop ," Modern control engineering", Addison Wesley, 1998
4. MAPLE V programming guide
5. MATLAB/ SIMULINK user manual
6. MATHCAD / VIS SIM user manual

EI15A5 PIPING AND INSTRUMENTATION DESIGN 3 0 0 3

1. LOW SHEETS **9**

Types of flow sheets, Flow sheet Presentation, Flow Sheet Symbols, Process flow diagram- Synthesis of steady state flow sheet - Flow sheeting software.

2. P & I D SYMBOLS **9**

P & I Drawing objectives, P & I Drawing guide rules, P & I Drawing Symbols, Line numbering, Line schedule, P & I Drawing development, typical stages of P & I Drawing .

3. P & I D FOR DIFFERENT EQUIPMENTS **9**

P & I Drawing for linear system - P & I Drawing for rotating equipment - P & I Drawing for static pressure vessels - P & I Drawing for Process vessels - P & I Drawing for absorber - P & I Drawing for evaporator.

4. CONTROL SYSTEM DEVELOPMENT **9**

Control System for Heater, Control System for Heat exchangers, Control System for reactors, Control System for dryers, Control System for Distillation column, Control System for Temperature , Flow and Level process

5. APPLICATIONS OF P & ID **9**

Applications of P & I D in design stage - Construction stage - Commissioning stage - Operating stage - Revamping stage - Applications of P & I D in HAZOPS and Risk analysis.

TOTAL = 45 PERIODS

TEXT BOOKS:

1. Ernest E. Ludwig, "Applied Process Design for Chemical and Petrochemical Plants", Vol.-I Gulf Publishing Company, Houston, 1989.
2. Max. S. Peters and K.D.Timmerhaus, "Plant Design and Economics for Chemical Engineers", McGraw Hill, Inc., New York, 1991.

REFERENCES:

1. Anil Kumar,"Chemical Process Synthesis and Engineering Design", Tata McGraw Hill publishing Company Limited, New Delhi - 1981.
   A.N. Westerberg, et al., "Process Flowsheeting", Cambridge University Press, 1979.

EI15A6 **ROBOTICS AND AUTOMATION** **3 0 0 3**

Prerequisite: None

1. INTRODUCTION **8**

Geometric configuration of robots – Manipulators – Drive systems – Internal and external sensors – End effectors – Control systems – Robot programming languages and applications – Introduction to robotic vision.

2. ROBOT ARM KINEMATICS **9**

Direct and inverse kinematics – Rotation matrices – Composite rotation matrices – Euler angle representation – Homogenous transformation – Denavit Hattenberg representation and various arm configuration.

3. ROBOT ARM DYNAMICS **9**

Lagrange formulation – Euler formulation - joint velocities – Kinetic energy – Potential energy – linear and rotational motion equations – Generalised D'Alembert equations of linear and rotational motion

4. PLANNING OF MANIPULATOR TRAJECTORIES 9

Major categories of planning-General consideration for planning – joint interpolated trajectory - types of trajectory – calculation of a 4-3-4 joint trajectory - Cartesian space descriptions –planning of Cartesian space trajectory - A two link manipulator trajectories.

5. CONTROL OF ROBOT MANIPULATORS 10

PID control computed, torque technique – Near minimum time control – Variable structure control – Non-linear decoupled feedback control – Resolved motion control and adaptive control.

TOTAL = 45 PERIODS

REFERENCES

1. Fu, K.S. Gonazlez, R.C. and Lee, C.S.G., "Robotics (Control, Sensing, Vision and Intelligence), McGraw-Hill, 1968 (II printing).
2. Wesley, E. Sryda, "Industrial Robots: Computer interfacing and Control" PHI, 1985.
3. Asada and Slotine, "Robot Analysis and Control", John Wiley and Sons, 1986.
4. Philippe Coiffet, "Robot Technology" Vol. II (Modelling and Control), Prentice Hall INC, 1981.
5. Saeed B. Niku, "Introduction to Robotics, Analysis, systems and Applications", Pearson Education, 2002
6. Groover M. P. Mitchell Wesis., "Industrial Robotics Technology Programming and Applications", Tata McGraw-Hill, 1986.

EI15A7 OPTIMAL CONTROL AND FILTERING 3 0 0 3

Prerequisite: Control System

1. INTRODUCTION 8

Statement of optimal control problem – Problem formulation and forms of optimal control – Selection of performance measures. Necessary conditions for optimal control – Pontryagin's minimum principle – State inequality constraints – Minimum time problem.

2. LQ CONTROL PROBLEMS AND DYNAMIC PROGRAMMING 10

Linear optimal regulator problem – Matrix Riccatti equation and solution method – Choice of weighting matrices – Steady state properties of optimal regulator – Linear tracking problem – LQG problem – Computational procedure for solving optimal control problems – Characteristics of dynamic programming solution – Dynamic programming application to discrete and continuous systems – Hamilton Jacobi Bellman equation.

3. NUMERICAL TECHNIQUES FOR OPTIMAL CONTROL 8

Numerical solution of 2-point boundary value problem by steepest descent method solution of Ricatti equation by negative exponential and interactive methods - solution of 2-point boundary value problem by Fletcher Powell method solution of Ricatti equation by negative exponential and interactive methods

4. FILTERING AND ESTIMATION 9

Filtering – Linear system and estimation – System noise smoothing and prediction – Gauss Markov discrete time model – Estimation criteria – Minimum variance estimation – Least square estimation – Recursive estimation.

5. KALMAN FILTER AND PROPERTIES 10

Filter problem and properties – Linear estimator property of Kalman Filter – Time invariance and asymptotic stability of filters – Time filtered estimates and signal to noise ratio improvement – Extended Kalman filter.

TOTAL = 45 PERIODS

REFERENCES

1. Krik D.E., "Optimal Control Theory – An introduction", Prentice hall, N.J., 1970.
2. Sage, A.P., "Optimum System Control", Prentice Hall N.H., 1968.
3. Anderson, BD.O. and Moore J.B., "Optimal Filtering", Prentice hall Inc., N.J., 1979.
4. S.M. Bozic, "Digital and Kalman Filtering", Edward Arnould, London, 1979.
5. Astrom, K.J., "Introduction to Stochastic Control Theory", Academic Press, Inc, N.Y., 1970.

EI15A8 EMBEDDED CONTROL SYSTEM DESIGN 3 0 0 3

1. EMBEDDED SYSTEM ORGANIZATION 9

Embedded computing – characteristics of embedded computing applications –embedded system design challenges; Build process of Realtime Embedded system –Selection of processor; Memory; I/O devices-Rs-485, MODEM, Bus Communicationsystem using I2C, CAN, USB buses, 8 bit –ISA, EISA bus.

2. REAL-TIME OPERATING SYSTEM 9

Introduction to RTOS; RTOS- Inter Process communication, Interrupt driven Input and Output -Nonmaskable interrupt, Software interrupt; Thread – Single, Multithread concept; Multitasking Semaphores - Real time system software – Survey on basics of contemporary RTOS – VXWorks, UC/OS-II.

3. INTERFACE WITH COMMUNICATION PROTOCOL 9

Design methodologies and tools – design flows – designing hardware and software Interface . – system integration; SPI, High speed data acquisition and interface-SPI read/write protocol, RTC interfacing and programming

4. SOFTWARE FOR EMBEDDED CONTROL 9

Software abstraction using Mealy-Moore FSM controller, Layered software development, Basic concepts of developing device driver – SCI – Software - interfacing & porting using standard C & C++ ; Functional and performance Debugging with benchmarking.

5. CASE STUDIES WITH EMBEDDED CONTROLLER **9**

Programmable interface with A/D & D/A interface, serial communication interface- Digital implementation of control Schemes - PWM motor speed controller - FPGA implementation of PWM control.

TOTAL: 45 PERIODS

REFERENCES:

1. Steven F. Barrett, Daniel J. Pack, "Embedded Systems – Design and Applications with the 68HC 12 and HCS12", Pearson Education, 2008.
2. Raj Kamal, "Embedded Systems- Architecture, Programming and Design" Tata McGraw Hill, 2006.
3. Micheal Khevi, "The M68HC11 Microcontroller application in control, Instrumentation & Communication", PH NewJersy, 1997.
4. Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey, "PIC Microcontroller and Embedded Systems- Using Assembly and C for PIC18", Pearson Education, 2008.
5. Steven F.Barrett,Daniel J.Pack,"Embedded Systems-Design & Application with the 68HC12 & HCS12", Pearson Education,2008.
6. Daniel W. Lewis, "Fundamentals of Embedded Software", Prentice Hall India, 2004.
7. Jack R Smith "Programming the PIC microcontroller with MBasic" Elsevier, 2007.
8. Keneth J.Ayala, "The 8086 Microprocessor: Programming & Interfacing the PC", Thomson India edition, 2007.

EI15A9 MICRO AND NANO ELECTRO MECHANICAL SYSTEMS 3 0 0 3

UNIT I **9**

History of Micro Electro Mechanical Systems , Micro Electro Mechanical Systems and Microsystems, Scaling laws in Miniaturization. Materials for Micro Electro Mechanical Systems and Microsystems.

UNIT II **9**

Microsystem Design and Fabrication, Microsystem fabrication processes - Photolithography, Ion Implantation, Diffusion, Oxidation, Chemical and Physical Vapor deposition, Deposition by Epitaxy, Etching. Bulk Micro manufacturing, Surface micromachining, LIGA process.

UNIT III **9**

Design of Acoustic wave sensors, Design of resonant sensor, Design of Vibratory gyroscope, Design of Capacitive and Piezo Resistive Pressure sensors- engineering mechanics behind these Microsensors.

UNIT IV **9**

Semiconductor synthesization techniques, electronic structure and physical processes in semiconductor nanostructures, principles and performance of semiconductor nanostructure based electronic and electro-optical devices

UNIT V **9**

Nano-Electromechanical systems - fabrication process- choice of materials, calculations - the performance of different structures - advantages and disadvantages of different approaches, thermal – radiation, magnetic,chemical, and mechanical sensors, Microactuators.

TOTAL: 45 PERIODS

REFERENCES:

1. Marc Madou, "Fundamentals of Microfabrication", CRC press 1997.
2. Stephen D. Senturia," Micro system Design", Kluwer Academic Publishers,2001
3. B.H. Bao, "Analysis and design principles of MEMS Devices", Elsevier, 2005.
4. Tai Ran Hsu ,"MEMS and Microsystems Design and Manufacture" ,Tata Mcraw Hill, 2002.
5. Chang Liu, "Foundations of MEMS", Pearson education India limited, 2006,
6. Verdeyen. J, Laser Electronics, II Edition, Prentice Hall, 1990.
7. W.R.Farhner, "Nanotechnology and Nanoelectronics- Materials, Devices and Measurement Techniques" Springer(2006)

EI15B1 PROCESS MODELLING AND SIMULATION 3 0 0 3

1. INTRODUCTION TO MODELLING **9**

Introduction to modelling, a systematic approach to model building, classification of models. Conservation principles of process systems, thermodynamic principles of process systems.

2. DEVELOPMENT OF BASIC MODELS **9**

Development of steady state model Development of dynamic model Development of lumped and distributed parameter models based on first principles. Analysis of ill-conditioned systems.

3. DEVELOPMENT OF STATISTICAL MODEL **9**

Development of grey box models. Development of Empirical model building. Development of Statistical model -calibration and validation of system. Development of Population balance models-Examples.

4. SOLUTION METHODS FOR LUMPED PARAMETER MODELS **9**

Solution strategies for lumped parameter models. Stiff differential equations. Solution methods for initial value and boundary value problems. Euler's method. R-K method, shooting method, finite difference methods. Solving the problems using MATLAB/SCILAB.

5. SOLUTION STRATEGIES FOR DISTRIBUTED PARAMETER MODELS **9**

Solution strategies for distributed parameter models. Solving parabolic differential equations, elliptic differential equations and hyperbolic differential equations partial differential equations. Finite element and finite volume methods.

TOTAL = 45 PERIODS

REFERENCES:

1. K. M. Hangos and I. T. Cameron, "Process Modelling and Model Analysis", Academic Press, 2001.
2. W.L. Luyben, "Process Modelling, Simulation and Control for Chemical Engineers", 2nd Edn., McGraw Hill Book Co., New York, 1990.
3. W. F. Ramirez, "Computational Methods for Process Simulation", Butterworths, 1995.
4. Mark E. Davis, "Numerical Methods and Modelling for Chemical Engineers", John Wiley & Sons, 1984.
5. Singiresu S. Rao, "Applied Numerical Methods for Engineers and Scientists" Prentice Hall, Upper Saddle River, NJ, 2001