M.Tech. Degree

IN

PROCESS CONTROL AND INSTRUMENTATION

SYLLABUS
FOR
CREDIT BASED CURRICULUM
(For students admitted in 2016-17)

DEPARTMENT OF CHEMICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI – 620 015
TAMIL NADU, INDIA

VISION

To provide valuable resources for industry and society through excellence in technical education and research

MISSION

- To offer state of the art undergraduate, postgraduate and doctoral programmes.
- To generate new knowledge by engaging in cutting edge research.
- To undertake collaborative projects with academia and industries.
- To develop human intellectual capability to its fullest potential.

DEPARTMENT OF CHEMICAL ENGINEERING

VISION

- To be a world class Chemical Engineering Department.

MISSION

- To produce globally competent professional chemical engineers.
- To foster process engineering knowledge through research and innovation.
- To serve organization and society as adaptable engineers, entrepreneurs or leaders.

PROGRAMME EDUCATIONAL OBJECTIVES

PEO1	A successful career in Process Control, Instrumentation, Automation and inter-disciplinary fields.
PEO2	Research and contribution to technological development in the fields of Process Control and Instrumentation
PEO3	Attaining professional competency to address the technological needs of society and industrial problems.
PEO4	Exhibiting project management skills and ability to work in collaborative environment.
PEO5	Life-long independent and reflective learning skills in their career.

Mapping of Departmental Mission Statements with Programme Educational Objectives

Mission	PEO1	PEO2	PEO3	PEO4	PEO5
To produce globally competent professional chemical engineers.	✓	✓	✓	✓	✓
To foster process engineering knowledge through research and innovation.	✓	✓	✓		✓
To serve organization and society as adaptable engineers, entrepreneurs or leaders.	✓	✓	✓	✓	✓

PROGRAMME OUTCOMES:

PO1	To apply knowledge of mathematics, science and engineering in practice,
PO2	To identify, critically analyse, formulate and solve engineering problems with comprehensive knowledge in the area of specialization,
PO3	To select modern engineering tools and techniques and use them with dexterity,
PO4	To design processes systems and provide solutions considering health, safety, manufacturability, societal and environmental factors,
PO5	To contribute solutions to engineering problems by research and innovation,
PO6	To devise and conduct experiments, interpret data and provide meaningful and unbiased conclusions,
PO7	To understand the impact of engineering solutions in a contemporary, global, economic, environmental and societal context for sustainable development,
PO8	To document professionally his/her work for effective dissemination of knowledge,
PO9	To function professionally with ethical responsibility as an individual as well as in multidisciplinary teams with positive attitude,
PO10	To effectively communicate with the engineering community and with the society at large and capable of presenting reports and design documentation by adhering to appropriate standards.
PO11	To understand the role of a leader, leadership principles and attitude conducive to effective professional practice.
PO12	To appreciate the importance of goal-setting and to recognize the need for life-long reflective learning.

Mapping of Programme Outcomes with Programme Educational Objectives

	PEO1	PEO2	PEO3	PEO4	PEO5
PO1	✓	✓	✓	✓	✓
PO2	✓	✓	✓	✓	✓
PO3	✓	✓		✓	✓
PO4	✓	✓	✓	✓	
PO5	✓	✓	✓		✓
PO6	✓	✓	✓		
PO7	✓	✓	✓	✓	✓
PO8			✓	✓	
PO9	✓	✓	✓	✓	✓
PO10	✓	✓	✓	✓	✓
PO11	✓		✓	✓	✓
PO12	✓	✓	✓	✓	✓

CURRICULAR COMPONENTS

Category	**Credits offered**
Core Courses	18
Elective Courses	18
Laboratory	2
Extra Mural Lectures	2
Project Work	24
Total	**64**

Curriculum

The total minimum credits required for completing the M.Tech. Programme in Process Control and Instrumentation Engineering is 64.

SEMESTER I

CODE	COURSE OF STUDY	L	T	P	C
CL 651 A/B	Measurement Systems / Chemical Process Systems	3	0	0	3
CL 653	Modern Control Engineering	3	0	0	3
CL 601	Advanced Process Control	3	0	0	3
	Elective – 1	3	0	0	3
	Elective – 2	3	0	0	3
	Elective – 3	3	0	0	3
CL 655	Process Control & Instrumentation Laboratory	0	0	6	2
	TOTAL	18	0	6	20

SEMESTER II

CODE	COURSE OF STUDY	L	T	P	C
CL 652	Computational Techniques in Control Engineering	3	0	0	3
CL 654	Chemical Process Flow-Sheeting	2	1	0	3
CL 656	Industrial Instrumentation	3	0	0	3
	Elective – 4	3	0	0	3
	Elective – 5	3	0	0	3
	Elective – 6	3	0	0	3
CL 658	Extramural Lecture Series	0	0	0	2
	TOTAL	17	1	0	20

SEMESTER III

CODE	COURSE OF STUDY	L	T	P	C
CL 697	Project work Phase – I	0	0	24	12

SEMESTER IV

CODE	COURSE OF STUDY	L	T	P	C
CL 698	Project work Phase – II	0	0	24	12

Electives for Semester I

CODE	COURSE OF STUDY	L	T	P	C
CL 661	Applied Mathematics for Process Control & Instrumentation	3	0	0	3
CL 663	Signal Conditioning and Processing	3	0	0	3
CL 665	Computer Control of Processes	3	0	0	3
CL 667	Analytical Instrumentation	3	0	0	3
CL 669	Soft Computing Techniques	3	0	0	3
CL 671	Multi Sensor Data Fusion	3	0	0	3
CL673	Advanced Instrumentation and controls in Pulp and Paper Industry				

Electives for Semester II

CODE	COURSE OF STUDY	L	T	P	C
CL 662	Logic & Distributed Control Systems	3	0	0	3
CL 664	Industrial Data Communication Systems	3	0	0	3
CL 668	System Identification and Adaptive control	3	0	0	3
CL 670	Micro Electro Mechanical Systems	3	0	0	3
CL 672	Optimal Control	3	0	0	3
CL 673	Real-Time and Embedded Systems	3	0	0	3
CL 674	Image Processing	3	0	0	3

Electives offered from other Departments

CODE	COURSE OF STUDY	L	T	P	C
HS 611	Technical Communication	3	0	0	3
EN 631	Instrumentation and Control in Energy Systems	3	0	0	3
ME 657	Safety in Engineering Industry	3	0	0	3
HS 601	Human Resource Management	3	0	0	3

List of Open Electives

CODE	COURSE OF STUDY	L	T	P	C
CL669	Soft Computing Techniques	**3**	**0**	**0**	**3**
CL672	Real-Time and Embedded Systems	**3**	**0**	**0**	**3**

CL 651-A MEASUREMENT SYSTEM

L	T	P	C
3	0	0	3

Course Objectives: This course is primarily to introduce various measurement techniques to students from non-circuit branches.

Course Content:
General concepts and terminology of measurement systems, static and dynamic characteristics, errors, standards and calibration.

Introduction, principle, construction and design of various active and passive transducers. Introduction to semiconductor sensors and its applications; Design of signal conditioning circuits for various Resistive, Capacitive and Inductive transducers and piezoelectric transducer.

Introduction to transmitters, two wire and four wire transmitters, Smart and intelligent Transmitters. Design of transmitters.

Introduction to EMC, interference coupling mechanism, basics of circuit layout and grounding, concept of interfaces, filtering and shielding.

Introduction to safety, electrical hazards, hazardous areas and classification, non-hazardous areas, enclosures – NEMA types, fuses and circuit breakers. Protection methods: Purging, explosion proofing and intrinsic safety.

Course Outcome:
Upon completing this course the student would learn thoroughly about
1. Basic measurement techniques
2. Sensing and transducting various physical quantities
3. Electromagnetic interference and data transfer
4. Safety in handling industrial instruments.

TEXT BOOKS:

1. John P. Bentley, *Principles of Measurement Systems*, Third edition, Addison Wesley Longman Ltd., UK, 2000.
2. Doebelin E.O, *Measurement Systems* - Application and Design, Fourth edition, McGraw-Hill International Edition, New York, 1992.

REFERENCES:

1. M. Sze, *Semiconductor sensors*, John Wiley & Sons Inc., Singapore, 1994.
2. Noltingk B.E., *Instrumentation Reference Book*, 2nd Edition, Butterworth Heinemann, 1995.
3. L.D.Goettsche, *Maintenance of Instruments and Systems – Practical guides for measurements and control*, ISA, 1995.

Course Outcome:

Upon completing this course the student would learn thoroughly about

CO1	basic measurement techniques
CO2	sensing and transducting various physical quantities
CO3	electromagnetic interference and data transfer
CO4	safety in handling industrial instruments.

Mapping of Course Outcome with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓		✓	✓	✓						✓
CO2	✓	✓	✓		✓	✓	✓	✓		✓		✓
CO3	✓	✓	✓		✓	✓	✓	✓		✓		✓
CO4		✓	✓	✓		✓	✓	✓		✓		✓

L	T	P	C
3	0	0	3

CL 651-B CHEMICAL PROCESS SYSTEMS

Course Objectives: This course is primarily to introduce various chemical processes and modeling to students from circuit branches.

Course Content:
Historical overview of Chemical Engineering: Concepts of unit operations and unit processes, and more recent developments, The Chemical Industry-scope, features & characteristics. Flow sheets, and symbols for various operations.

Material balances in simple systems involving physical changes and chemical reactions; systems involving recycle, purge, and bypass, combustion reactions, Forms of energy, optimum utilization of energy, Energy balance calculations in simple systems. Introduction to Computer aided calculations-steady state material and energy balances, combustion reactions.

Basic Fluid Concepts: Dimensions and Units, Velocity and Stress Fields, Viscosity and surface tension, Non Newtonian viscosity, Dimensional Analysis (Buckingham PI theorem), Types of flows, Methods of Analysis, Fluid Statics. Pipe flow, Pumps, Agitation and Mixing, Compressors.

Review of conduction, resistance concept, extended surfaces, lumped capacitance; Introduction to Convection, natural and forced convection, correlations; Radiation; Heat exchangers-Fundamental principles and classification of heat exchangers, Evaporators

Fundamental principles and classification of Distillations, Adsorption, Absorption, Drying, Extraction, Membrane Process. Energy and Mass Conservation in process systems and industries. Introduction to chemical reactors.

Course Outcome:
Upon completing this course, the student would understand
1. basic chemical process engineering.
2. fundamentals of fluid mechanics.
3. the working of heat exchangers.
4. the working of large scale industrial processes such as distillation columns and reactors.

TEXT BOOKS:
1. G.T. Austin, R.N. Shreve, *Chemical Process Industries*, 5th ed., McGraw Hill, 1984.
2. W.L. McCabe, J.C. Smith and P. Harriott, *Unit Operations of Chemical Engineering*, Sixth Edition, McGraw Hill, 2001.
3. R. M. Felder and R.W. Rousseau, *Elementary Principles of Chemical Processes*, 3rd ed., John Wiley, New York,2004.
4. L.B. Anderson and L.A. Wenzel, *Introduction to Chemical Engineering*, McGraw Hill, 1961.
5. H.S. Fogler, *Elements of Chemical Reaction Engineering*, 4th Ed., Prentice-Hall, 2006.

Course Outcome:

Upon completing this course, the student would understand

CO1	basic chemical process engineering.
CO2	fundamentals of fluid mechanics.
CO3	the working of heat exchangers.
CO4	the working of large scale industrial processes such as distillation columns and reactors.

Mapping of Course Outcome with Programme Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO2	✓		✓		✓	✓		✓		✓		✓
CO3	✓		✓		✓	✓		✓		✓		✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓

L T P C

3 0 0 3

CL 653 MODERN CONTROL ENGINEERING

Course Objectives:

1. To introduce and teach advanced methods and techniques of linear system analysis and design from modern and digital control theory, and emphasize their interrelation.
2. To introduce mathematical modeling, analysis, and design of a larger class of systems in a unified framework.

Course Content:

State-space Models – Review of vectors and matrices, Canonical Models from Differential Equations and Transfer Functions, Interconnection of subsystems.

Analysis of Linear State Equations – First order scalar differential equations, System modes and modal decomposition, State Transition Matrix, Time-varying matrix case.

Lyapunov's stability theory for Linear Systems – Equilibrium points and stability concepts, Stability definitions, Linear system stability, The Direct method of Lyapunov, Use of Lyapunov's method in feedback design.

Controllability & Observability – Definitions, Controllability/Observability Criteria, Design of state feedback control systems, Full-order and Reduced-order Observer Design, Kalman canonical forms, Stabilizability & Detectability.

Digital Control Systems, Closed-loop Feedback Sampled-Data Systems, Stability Analysis, Implementation of Digital Controllers.

Text Books:

1. Hespanha, J.P., *"Linear Systems Theory,"* Princeton Univ. Press, 2009.
2. Brogan, W.L., *"Modern Control Theory,"* 3/e, Prentice Hall, 1990.

References:

1. Sontag, E.D., *Mathematical Control Theory*, 2/e, Springer Verlag, 2014.
2. Hinrichsen, D., & Pritchard, A.J., *"Mathematical System Theory – I,"* Springer, 2010.

Course Outcome:

CO1	The student is exposed to an appropriate modern paradigm for the study of larger scale multi-input-multi-output systems.
CO2	The student understands the importance of linear algebra and matrix theory in designing practical control systems.
CO3	The student is motivated to study more general systems and their stability using Lyapunov's theory.
CO4	The student learns to implement modern control systems using a digital computer in the loop.

Mapping of Course Outcome with Programme Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO2	✓	✓	✓		✓		✓					✓
CO3	✓	✓	✓		✓		✓					✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓

CL 601 ADVANCED PROCESS CONTROL

L	T	P	C
3	0	0	3

Course Objective:
Expose students to the advanced control methods used in industries and research. This course prepares the student to take up such challenges in his profession.

Course Content:
Review of Systems: Review of first and higher order systems, closed and open loop response. Response to step, impulse and sinusoidal disturbances. Transient response. Block diagrams.

Stability Analysis: Frequency response, design of control system, process identification. PI Controller tuning - Zigler-Nichols and Cohen-Coon tuning methods, Bode and Nyquist stability criterion. Process identification.

Special Control Techniques: Advanced control techniques, cascade, ratio, feed forward, adaptive control, Smith predictor, internal model control, model based control systems.

Multivariable Control Analysis: Introduction to state-space methods, Control degrees of freedom analysis and analysis, Interaction, Bristol arrays, Niederlinski index - design of controllers, Tuning of multivariable PI controllers, Design of multivariable DMC and MPC .

Sample Data Controllers: Basic review of Z transforms, Response of discrete systems to various inputs. Open and closed loop response to step, impulse and sinusoidal inputs, closed loop response of discrete systems. Design of digital controllers. Introduction to PLC and DCS.

TEXT BOOKS:

1. D.R. Coughanour, S.E. LeBlanc, *Process Systems analysis and Control*, McGraw-Hill, 2nd Edition, 2009.
2. D.E. Seborg, T.F. Edger, and D.A. Millichamp, *Process Dynamics and Control*, John Wiley and Sons, 2nd Edition, 2004.

REFERENCES:

1. B.A.Ogunnaike and W.H.Ray, *Process Dynamics, Modelling and Control*, Oxford Press, 1994.
2. B.W. Bequette, *Process Control: Modeling, Design and Simulation*, PHI, 2006.
3. S. Bhanot, *Process Control: Principles and Applications*, Oxford University Press, 2008.

Course Outcome:

Upon completing the course, the student should have understood

CO1	controller tuning.
CO2	type of controller that can be used for specific problems in chemical industry.
CO3	design of controllers for interacting multivariable systems.
CO4	design of digital control systems

Mapping of Course Outcome with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓

CL 655 PROCESS CONTROL & INSTRUMENTATION LAB

L	T	P	C
0	0	6	2

Course Objectives

1. To provide students with hands-on experience to apply their practical knowledge in designing, testing and simulation of any instrumentation and process control system.
2. To provide practical experience to the students in simulation softwares and real time interfacing cards and also to make them familiar with important process control applications.

List of Experiments

1. Modeling of flow process using two point Method
2. Real time Position control of a servo system.
3. Simulation study of MEMS Cantilever Beam Characteristics.
4. Level Control using P, PI, PID Controllers
5. Ladder logic Programming using PLC
6. Thermocouple cold junction compensation
7. Design of temperature transmitter using RTD and XTR101
8. ADC and LCD interfacing with Microcontroller 8051
9. Stepper motor interfacing with MC8051
10. Real time Vibration control of a cantilever beam
11. On line system identification of a given system
12. Tank level control simulation in LABVIEW.
13. Temperature control of a water bath using LABVIEW DAQ card

Course Outcome:

On completion of this lab students will be familiar with

CO1	Design of signal conditioning circuit for a given sensor
CO2	Design and tuning of PI, PID controllers for different processes
CO3	Modeling of a given system
CO4	Implementation of simple closed loop control system in real time
CO5	Use of Microcontroller for the design of standalone instrumentation systems.

Mapping of Course Outcome with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓
CO2	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓
CO3	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓
CO4	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓
CO5	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓

CL 652 COMPUTATIONAL TECHNIQUES IN CONTROL ENGINEERING

L	T	P	C
3	0	0	3

Course Objectives:
This course is an adaptation of numerical methods pertaining to control engineering problems. The algorithms are set in a numerical algebraic framework and are designed and analyzed in a formal way.
Course Content:

Review of Linear Algebra - Vector spaces, Orthogonality, Matrices, Vector and Matrix Norms, Kronecker Product

Numerical Linear Algebra - Floating point numbers and errors in computations, Conditioning, Efficiency, Stability, and Accuracy, LU Factorization, Numerical solution of the Linear system Ax = b, QR factorization, Orthogonal projections, Least Squares problem, Singular Value Decomposition, Canonical forms obtained via orthogonal transformations.

Control Systems Analysis - Linear State-space models and solutions of the state equations, Controllability, Observability, Stability, Inertia, and Robust Stability, Numerical solutions and conditioning of Lyapunov and Sylvester equations.

Control Systems Design - Feedback stabilization, Eigenvalue assignment, Optimal Control, Quadratic optimization problems, Algebraic Riccati equations, Numerical methods and conditioning, State estimation and Kalman filter.

Large scale Matrix computations, Some Selected Software .

TEXTBOOKS/REFERENCES/RESOURCES:

1. B.N. Datta, *Numerical Methods for Linear Control Systems*, Academic Press/Elsevier, 2005 (Low cost Indian edition available including CD ROM).
2. G.H. Golub & C.F. Van Loan, *Matrix Computations*, 4/e, John Hopkins University Press, 2007 (Low cost Indian edition available from Hindustan Book Agency)
3. A. Quarteroni, F. Saleri, *Scientific Computing with MATLAB*, Springer Verlag, 2003.
4. www.scilab.org/download/

Course Outcome:

CO1	Upon completing this course, the student would be competent enough to develop software exclusively for control theoretic problems.

Mapping of Course Outcome with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓		✓					✓

CL 654 CHEMICAL PROCESS FLOW SHEETING

L	T	P	C
2	1	0	3

Pre Requisites: The students should have already learnt the chemical engineering fundamentals.

Course Objectives:

1. The major objective is to understand how to invent chemical process flowsheets, how to generate and develop process alternatives, and how to evaluate and screen them quickly.
2. To simulate the steady-state behavior of process flowsheets using a suitable simulation software.

Course Content:

Flowsheeting

Introduction, Symbols, Flowsheet presentation with examples, Manual flowsheet calculation, Constrains and their applications in flowsheet calculations, Types of flow sheets, Synthesis of steady state flow sheet, Flowsheeting software.

Sequential modular approach to flowsheeting

Solution, partitioning and tearing a flowsheet, convergence of tear streams with suitable example.

Flowsheeting by equation solving methods

Selection, decision and tearing of variables in a flowsheet with simple and complex examples

Flowsheet applications

P & I D development, typical stages of P & I D, 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.

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.
2. A.N. Westerberg, et al., *Process Flowsheeting*, Cambridge University Press, 1979.
3. Paul Benedek, *Steady state flow sheeting of Chemical Plants*, Elsevier Scientific Publishing company.

Course Outcome:

At the conclusion of this course the successful student should be able to

CO1	Understand the input/output structure of a flowsheet for a given manufacturing unit.
CO2	Synthesize and design flowsheet sub-systems, to develop the recycle structure(s).
CO3	Simulate the steady-state behavior of process flowsheets at each level of process development.

Mapping of Course Outcome with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓	✓	✓	✓		✓	✓		✓		
CO2		✓	✓	✓	✓		✓	✓		✓		
CO3		✓	✓	✓	✓		✓	✓		✓		

CL 656 INDUSTRIAL INSTRUMENTATION

L	T	P	C
3	0	0	3

Course Objectives:

To enable the students to understand the fundamentals of various types of industrial measurements.

Course Content:

Review of Industrial Instrumentation

Measurement of Force, Torque, Velocity, Acceleration, Pressure, Temperature, Flow, Level, Viscosity, Humidity & Moisture (Qualitative Treatment Only).

Measurement in thermal power plant

Selection, Installation and maintenance of Instruments used for the measurement of fuel flow, Air flow, Drum level, Steam pressure, Steam temperature and other parameters in thermal power plant – Analyzers - Dissolved Oxygen Analyzers- Flue gas Oxygen Analyzers-pH measurement-Coal/Oil Analyzer – Pollution Controlling Instruments

Measurement in Petrochemical Industry

Parameters to be measured in refinery and petrochemical industry-Temperature, Flow and Pressure measurements in Pyrolysis, catalytic cracking, reforming processes-Selection and maintenance of measuring instruments – Intrinsic safety.

Instrumentation for energy conservation & management and safety

Principle of energy audit, management & conservation and measurement techniques – Instrumentation for renewable energy systems – Energy management device (Peak load shedding) – Electrical and intrinsic safety - Explosion suppression and deluge systems – Flame arrestors, conservation vents and emergency vents – Flame, fire and smoke Detectors- Metal detectors.

Special Purpose Instrumentation

Toxic gas monitoring- Detection of Nuclear radiation – Water quality monitoring- Monitor measurement by neutron-Thermo-luminescent detectors – Measurement of length, mass, thickness, flow, level using nuclear radiation.

REFERENCE BOOKS:

1. D.Patranabis, Principles of Industrial Instrumentation, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1999.
2. John G Webster, Measurement, Instrumentation and Sensors Handbook, CRC press IEEE press
3. Liptak B.G, Instrumentation Engineers Handbook (Measurement), Chilton Book Co., 1994.
4. Reay D.A, Industrial Energy Conservation, Pergamon Press, 1977.
5. Hodge B.K, Analysis and Design of energy systems, Prentice Hall, 1988.
6. Liptak B.G, Instrument Engineers Handbook, Clinton Book Company, 1982
7. Ness S.A. Air monitoring for Toxic explosions, Air integrated Approach, Von Nostrand,1991.
8. Ewing G., Analytical Instrumentation hand book, Dekker,1991.

Course Outcome:

CO1	To have an adequate knowledge on basic industrial instrumentation.
CO2	Ability to prepare design documentation and execute the instrumentation requirements in various process industries

Mapping of Course Outcome with Programme Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1		✓	✓	✓	✓	✓	✓	✓		✓		✓
CO2		✓	✓	✓	✓	✓	✓	✓		✓		✓

CL 661 APPLIED MATHEMATICS FOR PCI

L	T	P	C
3	0	0	3

Course Objectives:

1. To impart skills to students in the mathematical tools necessary for the specialization.
2. To teach an array of concepts widely used in the academia and the industry.

Course Content:

Linear Algebra, Matrix Theory & Computations - Systems of linear equations, Matrices, Row-reduced echelon matrices. Vector spaces, Subspaces, Bases and dimension, Linear transformations, Matrix representation, Characteristic values and characteristic vectors of linear transformations, Diagonalizability, Cayley-Hamilton theorem, Invariant subspaces, Jordan forms, Inner product spaces, Orthonormal bases, Gram-Schmidt process.

Laplace Transformation and its Applications - Concept of Transforms, Laplace Transform and its existence, Properties, Evaluation, and inverse Laplace Transform.

Ordinary Differential Equations, Applications and Numerical Solution Techniques **-** Motivation and real life examples, First and second order linear equations, General Existence and Uniqueness theory, Linear systems, Periodic Solutions, Sturm-Liouville theory, Introduction to two-point Boundary value problems.

Introduction to Optimization, Linear Programming (Graphical method and Simplex method), Dynamic Programming (Multistage Decision Process, Principle of Optimality), Further Topics in Optimization, including Nonlinear Programming, Queuing Theory, Game Theory, Multi-Objective Optimization.

Introduction to Probability and Stochastic Processes - Basics of Probability Theory, Random Variables, Discrete and Continuous, moments and other functions of Random Variables, Limit Theorems and Inequalities

Reference Books:

1. Kreyszing, E., *"Advanced Engineering Mathematics,"* 10/e, John Wiley, 2010.
2. NPTEL Lectures in Mathematics.

Course Outcome:

CO1	Formulate engineering problems as mathematical problems
CO2	Have a basic understanding of numerical methods
CO3	Learn unconstrained and constrained optimization methods and applications
CO4	Ue mathematical software for the solution of engineering problems

Mapping of Course Outcome with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓		✓					✓
CO2	✓	✓	✓		✓		✓					✓
CO3	✓	✓	✓		✓		✓					✓
CO4	✓	✓	✓		✓		✓					✓

CL 663 SIGNAL CONDITIONING and PROCESSING

L	T	P	C
3	0	0	3

Course Objectives:

1. To impart practical skills in measurement techniques to students from non-electrical background
2. To teach an array of concepts widely used in the academia and the industry.

Course Content:

Introduction to Op-amps, Circuits with Resistive Feedback, Design of offset and drift compensation circuits, Frequency compensation, Instrumentation amplifiers, Isolation Amplifiers - Necessity for isolation amplifiers, industrial and medical applications of isolation amplifiers, Grounding and Shielding. Active filter circuits, Nonlinear circuits – comparators, peak detectors, sample-and-hold amplifier

Analog-Digital sampling, Introduction to A/D and D/A conversion, ADCs for signal conditioning, Hardware design techniques.

Characterization and classification of signals, Typical signal processing applications, Time domain representations of signals and systems, Discrete-time signals, Discrete-time systems, Characterization of LTI systems.

Transform domain representation of signals and systems, The discrete time Fourier transform, Discrete Fourier series, Discrete Fourier transform, Computation of DFT.

Basic structures for IIR systems, Basic structures for FIR systems.

TEXT BOOKS:

1. S. Franco, *Design with Operational Amplifiers & Analog Integrated Circuits*, 3/e, TMH, 2002
2. H S Kalsi, *Electronic Instrumentation*, 4/e, TMH, 2001.
3. Daniel H. Sheingold, *Analog-Digital Conversion Handbook*, 3/e Prentice-Hall, 1986.
4. D Patranabis, *Sensors and Transducers*, PHI, 2003.
5. J.G.Proakis, and D.G.Manolakis, *Digital Signal Processing: Principles, Algorithms, and Applications*, 4/e, Pearson Prentice Hall, 2007.

Course Outcome:

Upon completing this course student from non-electrical background would learn

CO1	about practical signal conditioning circuits.
CO2	about analog-digital conversion and hardware design techniques.
CO3	the fundamentals of digital signal processing.
CO4	analysis and design of IIR and FIR filters for digital signal processing.

Mapping of Course Outcome with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓	✓	✓		✓	✓		✓
CO2	✓	✓	✓		✓	✓	✓		✓	✓		✓
CO3	✓	✓	✓		✓	✓	✓		✓	✓		✓
CO4	✓	✓	✓		✓	✓	✓		✓	✓		✓

CL 665 COMPUTER CONTROL OF PROCESSES

L	T	P	C
3	0	0	3

Course Objectives:
To impart knowledge on sampled-data control systems, various discrete control algorithms, parameter estimation methods, and adaptive control algorithms.

Course Content:
Computer control – Introduction – Review of Z Transform, Modified Z Transform and Delta Transform. Relation between Discrete and Continuous Transfer function-Poles and Zeros of Sampled Data System (SDS) – Stability Analysis in Z domain

Introduction to Pulse Transfer function- Open loop and closed loop response of SDS- Design and implementation of different digital control algorithm: Dead beat, Dahlin, Smith predictor and Internal Model Control algorithm with examples.

Different Models of Discrete System: LTI System:- Family of Discrete Transfer function Models- State Space models- Distributed Parameter Model. Models for Time varying and Non-linear System: Linear Time varying models- Non-linear State space models- Non-linear Black Box Models- Fuzzy Models

Parameter Estimation Methods: General Principles- Minimizing Prediction errors- Linear Regression and the Least Square method- Statistical Frame work for Parameter Estimation and the Maximum Likely hood method- Instrument Variable method – Recursive and Weighted Least square method

Adaptive Control: Introduction -Deterministic Self Tuning Regulator: Indirect and Direct self tuning regulator-Model reference Adaptive system: Design of MRAS using Lyapnov and MIT Rule- Auto tuning and Gain scheduling adaptive control design with examples.

Course Outcome:
After completing this course, the student is exposed to
1. the fundamentals of various discrete-time systems.
2. employing a digital computer in the process loop.
3. curve fitting from the data and estimation techniques.
4. adaptive control paradigm.

TEXT BOOK:

1. Lennart Ljung,*System Identification Theory for the user*, Prentice Hall Information and system sciences Series, NJ, 1999.
2. P. Deshponde and Ash, *Computer Controlled System*, ISA Press, USA
3. Richard H. Middleton and Graham C. Goodwin, *Digital Control and Estimation A Unified Approach*, Prentice Hall NJ, 1990
4. Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp, *Process Dynamics and Control*,Willey India, 2006.
5. Astrom .K. J, Bjorn Wittenmark, *Adaptive Control*, Second Edition, Prentice Hall of India, New Delhi, 1994.

Course Outcome:
After completing this course, the student is exposed to

CO1	the fundamentals of various discrete-time systems.
CO2	employing a digital computer in the process loop.
CO3	curve fitting from the data and estimation techniques.
CO4	adaptive control paradigm.

Mapping of Course Outcome with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓	✓	✓		✓	✓		✓
CO2	✓	✓	✓		✓	✓	✓		✓	✓		✓
CO3	✓	✓	✓		✓	✓	✓		✓	✓		✓
CO4	✓	✓	✓		✓	✓	✓		✓	✓		✓

CL 667 ANALYTICAL INSTRUMENTATION

L	T	P	C
3	0	0	3

Course Objectives: To understand different instrumentation techniques for measurement of environmental parameters

Course Content:

Electromagnetic radiation, Characteristics - Interaction of e.m. radiation with matter - Spectral methods of analysis - absorption spectroscopy - Beer's law - radiation sources - monochromators and filters - diffraction grating - ultraviolet spectrometer - single beam and double beam instruments.

Particles emitted in radioactive decay - nuclear radiation detectors - injection chamber - Geiger - Muller counter - proportional counter - scintillation counter - Semiconductor detectors.

Measurement techniques for water quality parameters - conductivity - temperature - turbidity. Measurement techniques for chemical pollutants - chloride - sulphides - nitrates and nitrites - phosphates - fluoride - phenolic compounds.

Air pollution: its effect on environment, its classification, Measurement techniques for particulate matter in air. Measurement of oxides of sulphur, oxides of nitrogen unburnt hydrocarbons, carbon-monoxide, dust mist and fog.

Noise pollution: basics of sound pollution, its effect to environment, measurement of sound, tolerable levels of sound. Measurement of sound level. Measurement techniques for soil pollution.

TEXT BOOKS:

1. H.H. Willard, Merrit and Dean, *Instrumental Methods of Analysis*, 5th Edn., 1974.
2. R.K. Jain, *Fundamentals of Mechanical and Industrial Instrumentation*",1999.

REFERENCES:

1. S.P. Mahajan, *Pollution Control in Process Industries*, Tata McGraw Hill, 2004.
2. G. N. Pandey and G.C. Carney, *Environmental Engineering*, Tata McGraw-Hill, 2004.

Course Outcome:

CO1	After completing the course, the students should be able to understand spectral methods, methods for water quality, air quality, sound and soil pollution.

Mapping of Course Outcome with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1				✓	✓	✓	✓	✓	✓	✓		✓

CL 669 SOFTCOMPUTING TECHNIQUES

L	T	P	C
3	0	0	3

Course Objectives:

1. This course is designed to expose students to ANN, fuzzy methods of analyzing problems which involve incomplete or vague criteria rather than complete data sets. The course investigates requirements analysis, logical design, and technical design of components for fuzzy systems development.
2. The subject is primarily concerned with the definitions and concepts associated with a fuzzy set, Fuzzy reasoning, Fuzzy design and Fuzzy logic applications. The course also introduces Neuro-Fuzzy systems, Fuzzy Genetic Algorithms.

Course Content:

Overview of Artificial Neural Network (ANN) & Fuzzy Logic

Review of fundamentals - Biological neuron, Artificial neuron, Activation function, Single Layer Perceptron - Limitations - Multi Layer Perceptron - Back propagation algorithm (BPA); Fuzzy set theory - Fuzzy sets - Operation on Fuzzy sets - Scalar cardinality, fuzzy cardinality, union and intersection, complement, equilibrium points, aggregation, projection, composition, decomposition, cylindrical extension, fuzzy relation - Fuzzy membership functions.

Neural Networks for Modeling and Control

Modeling of nonlinear systems using ANN- NARX,NNSS,NARMAX - Generation of training data - optimal architecture - Model validation- Control of nonlinear system using ANN- Direct and Indirect neuro control schemes- Adaptive neuro controller - Familiarization of Neural Network Control Tool Box.

ANN Structures and Online Training Algorithms

Recurrent neural network (RNN) - Adaptive resonance theory (ART) based network- Radial basis function network- Online learning algorithms: BP through time - RTRL algorithms - Least Mean square algorithm - Reinforcement learning.

Fuzzy Logic for Modeling and Control

Modeling of nonlinear systems using fuzzy models - TSK model - Fuzzy Logic controller - Fuzzification - Knowledge base - Decision making logic - Defuzzification - Adaptive fuzzy systems - Familiarization of Fuzzy Logic Tool Box.

Hybrid Control Schemes

Fuzzification and rule base using ANN- Neuro fuzzy systems - ANFIS - Fuzzy Neuron - Introduction to GA - Optimization of membership function and rule base using Genetic Algorithm - Introduction to Support Vector Machine- Evolutionary Programming-Particle Swarm Optimization - Case study - Familiarization of ANFIS Tool Box.

TEXT BOOKS

1. Laurence Fausett, *Fundamentals of Neural Networks*, Prentice Hall, Englewood cliffs, N.J.,1992.
2. Timothy J.Ross, *Fuzzy Logic with Engineering Applications*, McGraw Hill Inc., 1997.
3. Goldberg, *Genetic Algorithm in Search, Optimization and Machine Learning*, Addison Wesley Publishing Company, Inc. 1989.
4. Millon W.T., Sutton R.S., and Webrose P.J., *Neural Networks for Control*, MIT Press, 1992.

5. Ethem Alpaydin, *Introduction to Machine Learning* (Adaptive Computation and Machine Learning Series), MIT Press, 2004.
6. Corinna Cortes and V. Vapnik, *Support - Vector Networks*, *Machine Learning*,12, 1995.
7. Zhang, Huaguang, Liu, Derong, *Fuzzy Modeling and Fuzzy Control Series: Control Engineering*, 2006.

Course Outcome:

Upon the completion of the course, the students will be able to

CO1	Understand the overview of ANN and Fuzzy logic theory.
CO2	Solve and design various ANN models.
CO3	Apply and analyze the concept to existing systems.
CO4	Design of hybrid systems for engineering applications

Mapping of Course Outcome with Programme Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓		✓	✓	✓		✓	✓		✓
CO2	✓	✓	✓		✓	✓	✓		✓	✓		✓
CO3	✓	✓	✓		✓	✓	✓		✓	✓		✓
CO4	✓	✓	✓		✓	✓	✓		✓	✓		✓

CL 671 MULTI SENSOR DATA FUSION

L	T	P	C
3	0	0	3

Course Objectives:
To learn the concepts and techniques used in sensor data fusion.

Course Content:
Multisensor data fusion: Introduction, sensors and sensor data, Use of multiple sensors, Fusion applications. The inference hierarchy: output data. Data fusion model. Architectural concepts and issues. Benefits of data fusion, Mathematical tools used: Algorithms, co-ordinate transformations, rigid body motion. Dependability and Markov chains, Meta - heuristics.

Taxonomy of algorithms for multisensor data fusion. Data association. Identity declaration.

Estimation: Kalman filtering, practical aspects of Kalman filtering, extended Kalman filters. Decision level identify fusion. Knowledge based approaches.

Data information filter, extended information filter. Decentralized and scalable decentralized estimation. Sensor fusion and approximate agreement. Optimal sensor fusion using range trees recursively. Distributed dynamic sensor fusion.

High performance data structures: Tessellated, trees, graphs and function. Representing ranges and uncertainty in data structures. Designing optimal sensor systems with in dependability bounds. Implementing data fusion system.

TEXT BOOKS:

1. David L. Hall, *Mathematical techniques in Multisensor data fusion*, Artech House, Boston, 1992.
2. R.R. Brooks and S.S.Iyengar, *Multisensor Fusion: Fundamentals and Applications with Software*, Prentice Hall Inc., New Jersey, 1998.

REFERENCES:

1. Arthur Gelb, *Applied Optimal Estimation*, M.I.T. Press, 1982.
2. James V. Candy, *Signal Processing: The Model Based Approach*, McGraw –Hill Book Company, 1987.

Course Outcome:
Upon completion of this course the students will be able to

CO1	Understand the concept of sensor fusion.
CO2	Apply algorithms for multisensor data fusion.
CO3	Interpret high performance data structures.

Mapping of Course Outcome with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	
CO2	✓	✓	✓		✓	✓	✓		✓	✓		✓
CO3	✓	✓	✓		✓	✓	✓		✓	✓		✓

CL 662 LOGIC AND DISTRIBUTED CONTROL SYSTEMS

L	T	P	C
3	0	0	3

Prerequisite: Fundamental knowledge of process control.

Course Objective: This course is designed to expose students to understand the process automation concepts like Programmable logic controller and Distributed control system.

Course Content:
Review of computers in process control: Data loggers, Data Acquisition Systems (DAS), Direct Digital Control (DDC). Supervisory Control and Data Acquisition Systems (SCADA), sampling considerations. Functional block diagram of computer control systems. alarms, interrupts. Characteristics of digital data, controller software, linearization. Digital controller modes: Error, proportional, derivative and composite controller modes.

Programmable logic controller (PLC) basics: Definition, overview of PLC systems, input/output modules, power supplies, isolators. General PLC programming procedures, programming on-off inputs/ outputs. Auxiliary commands and functions: PLC Basic Functions: Register basics, timer functions, counter functions.

PLC intermediate functions: Arithmetic functions, number comparison functions, Skip and MCR functions, data move systems. PLC Advanced intermediate functions: Utilizing digital bits, sequencer functions, matrix functions. PLC Advanced functions: Alternate programming languages, analog PLC operation, networking of PLC, PLC-PID functions, PLC installation, troubleshooting and maintenance, design of interlocks and alarms using PLC. Creating ladder diagrams from process control descriptions.

Interface and backplane bus standards for instrumentation systems. Field bus: Introduction, concept. HART protocol: Method of operation, structure, operating conditions and applications. Smart transmitters, examples, smart valves and smart actuators.

Distributed control systems (DCS): Definition, Local Control (LCU) architecture, LCU languages, LCU - Process interfacing issues, communication facilities, configuration of DCS, displays, redundancy concept - case studies in DCS.

Text Books:

1. John.W.Webb, Ronald A Reis, *Programmable Logic Controllers - Principles and Applications*, 4th Edition, Prentice Hall Inc., New Jersey, 1998.
2. M.P Lukcas, *Distributed Control Systems*, Van Nostrand Reinhold Co., New York, 1986.
3. Frank D. Petruzella, *Programmable Logic Controllers*, 2nd Edition, McGraw Hill, New York, 1997.

Reference Books:

1. P.B.Deshpande and R.H Ash, *Elements of Process Control Applications*, ISA Press, New York, 1995.
2. Curtis D. Johnson, *Process Control Instrumentation Technology*, 7th Edition, Prentice Hall, New Delhi, 2002
3. Krishna Kant, *Computer-based Industrial Control*, Prentice Hall, New Delhi, 1997.

Course Outcome:

Upon completion of the course, the student will be able to

CO1	Understand the popular process automation technologies.
CO2	Design and development of different PLC programming for simple process applications.
CO3	Understand the different security design approaches, Engineering and operator interface issues for designing Distributed control system.
CO4	Know the latest communication technologies like HART and Field bus protocol.

Mapping of Course Outcome with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓

CL 664 INDUSTRIAL DATA COMMUNICATION SYSTEMS

L	T	P	C
3	0	0	3

Course Objectives:
The objective of this course is to expose students to Communication systems emerged in the field. As the industry is progressing towards adopting these methods to build large scale Automation systems, this course prepares the student to take up such challenges in his Industrial Environment.

Course Content:
Interface: Introduction, Principles of interface, serial interface and its standards. Parallel interfaces and buses.

Fieldbus: Use of fieldbuses in industrial plants, functions, international standards, performance, use of Ethernet networks, fieldbus advantages and disadvantages. Fieldbus design, installation, economics and documentation.

Instrumentation network design and upgrade: Instrumentation design goals, cost optimal and accurate sensor networks. Global system architectures, advantages and limitations of open networks, HART network and Foundation fieldbus network.

PROFIBUS-PA: Basics, architecture, model, network design and system configuration. Designing PROFIBUS-PA and Foundation Fieldbus segments: general considerations, network design.

TEXT BOOKS/REFERENCES:

1. Noltingk B.E., *Instrumentation Reference Book*, 2nd Edition, Butterworth Heinemann, 1995.
2. B.G. Liptak, *Process software and digital networks*, 3rd Edition, CRC press, Florida.

Course Outcome:

CO1	Upon completing the course, the student should have understood the concepts required for building industrial systems.

Mapping of Course Outcome with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓

CL 666 SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL

L	T	P	C
3	0	0	3

Course Objectives:
Expose students to the system identification and adaptive control methods used in industries and research.

Course Content:
Introduction to system identification: identification based on differential equations, Laplace transforms, frequency responses, difference equations. Signals and system concepts, stationarity, auto-correlation, cross-correlation, power spectra. Random and deterministic signals for system identification: pulse, step, pseudo random binary sequence (PRBS).

Nonparametric model estimation: Correlation and spectral analysis for non-parametric model identification, obtaining estimates of the plant impulse, step and frequency responses from identification data.

Prediction-Error Model Structures: 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.

Adaptive Control: Close loop and open loop adaptive control. Self-tuning controller. Auto tuning for PID controllers: Relay feedback, pattern recognition, correlation technique.

Adaptive Smith predictor control: Auto-tuning and self-tuning Smith predictor. Adaptive advanced control: Pole placement control, minimum variance control, generalized predictive control.

TEXT BOOKS:
1. O.Nelles, *Nonlinear System Identification*, Springer-Verlag, Berlin, 2001.
2. Y.Zhu, *Multivariable System Identification for Process Control*, Pergamon, 2001.
3. L.Ljung, *System Identification: Theory for the User*, 2nd Edition, Prentice-Hall, 1999.
4. B.A. Ogunnaike and W.H. Ray, *Process Dynamics, Modeling, and Control*, Oxford University Press.

Course Outcome:
Upon completing the course, the student should have understood

CO1	Identification Methods
CO2	Estimation of Nonparametric models
CO3	Prediction-Error Model Structures
CO4	Adaptive control schemes.

Mapping of Course Outcome with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓

CL 668 MICRO-ELECTRO-MECHANICAL SYSTEMS

L	T	P	C
3	0	0	3

Course Objectives:

This course is designed to provide an introduction to microsystem technology and fabrication technologies followed by basic sensing and actuation principles of microsensors and actuators.

Course Content:

Introduction, emergence, devices and application, scaling issues, materials for MEMS, Thin film deposition, lithography and etching.

Bulk micro machining***:*** Introduction, etch-stop techniques, dry etching, buried oxide process, silicon fusion bonding, and anodic bonding.

Surface micro machining***:*** Introduction, sacrificial layer technology, material systems in sacrificial layer technology, plasma etching, combined IC technology and anisotropic wet etching.

Microstereolithography: Introduction, Scanning Method, Projection Method, Applications. LIGA Process: Introduction, Basic Process and Application

MEMS devices, electronic interfaces, design, simulation and layout of MEMS devices using CAD tools.

TEXT BOOKS:

1. S.M. Sze, *Semiconductor Sensors*, John Wiley & Sons, INC., 1994.
2. M. Elwenspoek, R. Wiegerink, *Mechanical Microsensors*, Springer-Verlag Berlin Heidelberg, 2001.

REFERENCES:

1. Massood Tabib-Azar, *Microactuators - Electrical, Magnetic, Thermal*, Optical, Mechanical, Chemical and Smart structures, Kluwer Academic Publishers, New York, 1997.
2. Eric Udd , *Fiber Optic Smart Structures* , John Wiley & Sons, New York, 1995.

Course Outcome:

Upon undergoing this course, the student will be able to

CO1	Acquire knowledge in materials and methods to process sensors, actuators, and microsystems.
CO2	Analyse and describe of the functional behaviour of MEMS devices.

Mapping of Course Outcome with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓
CO2	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓

CL 670 OPTIMAL CONTROL

L	T	P	C
3	0	0	3

Course Objectives:

To impart knowledge on

1. Dynamic Programming
2. Calculus of variation
3. Pontryagin's Minimum Principle
4. Optimization techniques

Course Content:

Problem formulation - Mathematical model - Physical constraints - Performance measure Optimal control problem. Form of optimal control. Performance measures for optimal control problem. Selection a performance measure.

Dynamic Programming - Optimal control law - Principle of optimality. An optimal control system. A recurrence relation of dynamic programming - computational procedure. Characteristics of dynamic programming solution. Hamilton - Jacobi - Bellman equation. Continuous linear regulator problems.

Calculus of variations - Fundamental concepts. Functionals. Piecewise - smooth extremals Constrained extrema.

Variational approach to optimal control problems - Necessary conditions for optimal control - Linear regulator problems. Linear tracking problems. Pontryagin's minimum principle and state inequality constraints.

Minimum time problems - Minimum control - effort problems. Singular intervals in optimal control problems. Numerical determination of optimal trajectories - Two point boundary - valve problems. Methods of steepest decent, variation of extremals. Quasilinearization. Gradient projection algorithm.

Course Outcomes: Expose the students to the fundamentals of dynamic programming, calculus of variation and various optimization techniques.

TEXTBOOK:

1. Donald E. Kirk, *Optimal Control Theory: An Introduction*, Prentice-Hall networks series, 1970.
2. D. Subbram Naidu, Optimal Control Systems, CRC Press, 2002.

REFERENCES:

1. B. D. O. Anderson, J. B. Moore, *Optimal control linear Quadratic methods*, Prentice Hall of India, New Delhi, 1991.
2. A.P. Sage, C.C. White, *Optimum Systems Control*, Second Edition, Prentice Hall, 1977.

Course Outcome:

CO1	Expose the students to the fundamentals of dynamic programming, calculus of variation and various optimization techniques.

Mapping of Course Outcome with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓

CL 672 REAL TIME AND EMBEDDED SYSTEMS

L	T	P	C
3	0	0	3

Course Objectives:

1. To provide an understanding of hardware and software design and integration for embedded devices.
2. To provide knowledge of Real-time operating systems that can be used to enhance their skills in developing real-time embedded systems.

Course Content:

Review of basic concepts of Embedded Systems: Embedded system – Examples, Classifications, Characteristics, Generalized organization, hardware components, software for embedded systems, Microprocessor based system, microcontrollers – different types, RISC and CISC processors, Von Neumann and Harvard architecture, embedded systems design principles, Embedded software development tools.

Industrial Embedded Systems: Embedded Systems for monitoring and Control, Data Loggers - evolution, sampling concepts, aliasing, principles of data acquisition, ADC - types, characteristics; DAQ systems – components, analog I/O, digital I/O, Timing I/O, functional blocks, specifications, multichannel data acquisition, interrupt driven data acquisition, programming, DAC, Timer/Counter.

Embedded Systems for Remote Data Acquisition: Serial communication standards, Asynchronous Serial communication – principles, RS-232, RS-422 and RS-485 standards, UART programming, Interfacing embedded system to PC using UART communication, Synchronous serial communication, interfaces – principles and features of I2C, SPI, MicroWire, IEEE1394, USB interfaces.

Networks: GPIB for data acquisition – Over view, GPIB commands, GPIB programming, Expanding GPIB, IEEE488.2, SCPI, CAN bus, Embedded systems with wireless communication support – wireless communication standards, ZigBee, Bluetooth

Real Time Operating System for Embedded applications: Introduction to OS, types of OS, interrupts, tasks, process, threads, multitasking, semaphores, multiprocessing, multithreading, tasks scheduling, task communication, tasks synchronization, process states, process scheduling, resource sharing, features of RTOS, commercial RTOSs.
Embedded system development life cycle (EDLC)

Textbooks and Reference books:

1. Embedded System Design, Santanu Chattopadhyay, PHI (2013).
2. Embedded System Design, II Ed., Peter Marwedel, Springer, (2011).
3. ZigBee Wireless Networks and Tranceivers, Shahin Farahani, Newnes publications, (2008).
4. An Embedded Software Primer, David E. Simon, Pearson Education, (2000).
5. PC Based Instrumentation: Concepts and Practice, N. Mathivanan, PHI (2007).

Course Outcome:

On completion of this course students will be able to:

CO1	1. Identify the specific processor and design for embedded application development
CO2	2. To demonstrate their competence and ability to develop a real-time embedded systems

Mapping of Course Outcome with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓

	L	T	P	C
CL 674 IMAGE PROCESSING	**3**	**0**	**0**	**3**

Course Objectives:

1. Cover the basic analytical methods which are widely used in image processing. These include topics such as deterministic and stochastic modeling of images; linear and nonlinear filtering; and image transformations for coding and restoration.
2. Cover issues and technologies which are specific to images and image processing systems. We will introduce a wide range of current technologies that are having impact in the image processing field. We will also study the related areas such as human visual modeling, and display/printing device characteristics.
3. Develop a theoretical foundation of fundamental Digital Image Processing concepts. Provide mathematical foundations for digital manipulation of images; image acquisition; preprocessing; segmentation; Fourier domain processing; and compression.

Course Content:

Imaging Systems: Camera Imaging Model- Affine transformation, Warping, Perspective transformation and camera imaging model; Stereo vision-Epipolar geometry, Correspondence, Triangulation; Thermal Camera-Thermal science concepts of conductive, convective and radiation heat transfer, thermal capacitance, Thermal image interpretation; Lighting System-spectral power distribution (SPD) of light sources, Colorimetry : trichromatic vision, RGB colour specification system, CIE XYZ colour specification system, CIE standard illuminant; Medical Image Acquisition-X ray, fluoroscopy and angiography, CT angiography, MR Imaging.

Image Improvements & Analysis: Colour Spaces-RGB,LAB,CMY,YCC,HSV Colour Spaces, Colour Space Transformations; Image Enhancements -Histogram Modification, Contrast manipulation, Colour image enhancement, Multispectral image enhancement; Segmentation-Amplitude segmentation methods, Clustering segmentation methods, Region based segmentation methods; Morphological Operations-Binary image dilation and erosion, Binary image close and open operations, Grayscale image morphological operations;

Advanced Feature Extraction: Fractal modelling of real world images: Introduction to IFS-Chaos and measures, The computation of images from IFS codes, The Collage Theorem; HMM Model-Bayesian Network, Expectation-maximization, Hidden Markov Models, Viterbi Algorithm; Feature Extraction-Principle Component Analysis(PCA),Scale Invariant Feature Transform(SIFT),Speeded Up Robust Features(SURF).

Intelligent Vision System: Tracking-Kalmanfilter, Condensation; Motion Estimation-Detection and tracking of point features, Optical flow; Model based object recognition-Shape Analysis: Distance, perimeter, area measurements, Spatial Moments, Shape orientation descriptors. ModelMatching:Template Matching, Matched filtering; Classifications Model -Linear Discriminant/Perceptron Learning, Optimization by Gradient Descent, Support Vector Machines, K-Nearest-Neighbor Classification, Non-parametric Classification, Unsupervised Learning, Clustering, Vector Quantization, K-means

Case Studies: Vision based Quality Analysis,Shape Detection, Surveillance,Medical imaging, Thermal Imaging, Robotic Vision.

Text and Reference books:

1. William K. Pratt, “Digital Image Processing”, 3rd Ed., Wiley 2001.
2. Biophotonics, NPTEL Course by Dr. Manoj Varma, IISC Bangalore “http://nptel.ac.in/courses/117108037/11”
3. E Davies, “Computer and Machine Vision, Algorithms, Practicalities”, 4th Edition, Elsevier, 2012.
4. M.F.Barnsley, R.L.Devaney,B.B.Manderbrot,H.O.Peitgen,D.Saupe,R.F.Voss, “The Science of Fractal Images” Springer-Verlag,1988
5. Richard O. Duda, Peter E. Hart and David G. Stork, "Pattern Classification", John Wiley & Sons, 2001.

Course Outcome:

CO1	To become familiar with the basic concepts of various imaging systems.
CO2	To become familiar with the basic concepts of image improvement and analysis.
CO3	To become familiar with the basic concepts of advanced features of image extraction.
CO4	To become familiar with the image tracking ,filtering, model matching.

Mapping of Course Outcome with Programme Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓

HS 611 TECHNICAL COMMUNICATIONS

L	T	P	C
3	0	0	2

Objectives:

The objective of the course is

1. To develop the professional and communicational skills of learners in a technical environment.
2. To enable students acquire functional and technical writing skills.
3. To enable students acquire presentation skills to technical and non-technical audience.

Course Description:

This course intends to focus on the discourse structures of technical communication where students will become familiar with and aware of the major components and practices within the field. This course concentrates on advanced writing and other communication skills, Principles and procedure of technical writing; attention to analyzing audience and purpose, organizing information, designing graphic aids, and writing such specialized forms as abstracts, instructions, resumes, technical reports, proposals and manuals.

Learning Outcome:

Learners will be able to:

- Communicate to multiple professional audiences clearly and effectively through both written and verbal modes
- Identify weaknesses in their own writing and apply appropriate revision processes to strengthen communication
- Analyze rhetorical aspects of audience, purpose, and context to communicate technical information effectively in written, oral, and visual media.
- Recognize structures or genres typically used in science and engineering, understand the processes that produce them, and the organizational and stylistic conventions characteristic of them, and apply this knowledge to their own writing tasks.

Course Content

Communication:

Concepts, goals and levels of communication - General and technical communication - Significance of technical communication - Barriers to effective communication - Psychology of communication.

Oral Communication:

Tools and skills of communication - Presentation skills and Use of PowerPoint Slides, Public Speaking - Extempore / Prepared Speech - Requirements of oral communication - Body language and Nonverbal Cues - Difference between Group Discussion and Debate - Interview techniques.

Written Communication:

Effective Writing - Focus on Writing ; Coherence and Cohesion - Report Writing - CV and Resume Writing - Drafting Proposals, Research papers - preparation of technical / software manuals - Reader Perspective - Comprehending and Summarizing a text - Non verbal cues in Writing.

Developing Listening Skills:

Listening as an active skill - Kinds of Listening- Listening for general content; Listening for specific information - Intensive Listening - Developing effective listening skills; Barriers to effective listening skills - Listening Comprehension - Retention of facts, data & figures - Role of speaker in listening, Difference between note taking and note making.

Technology and Communication:
Telephone etiquette - Effective email messages - Editing skills - Use of charts and graphs using computer software - Elements of style in technical writing - Role of media in technology and communication - Library and Reference skills.

References:

1. Andrea J. Rutherford. (2007). *Basic Communication Skills for Technology*. New Delhi:
2. Pearson Education in South Asia.
3. R.C. Sharma and Krishnamohan. (2011). *Business Correspondence and Report Writing*. New Delhi: Tata McGraw Hill.
4. J. Herbert.(1965).*The Structure of Technical English*, London: Longman.
5. Ashraf Rizvi.(2005). *Effective Technical Communication*. New Delhi: Tata McGraw Hill.
6. David Lindsay. (1995). *A Guide to Scientific Writing*. Macmillan.
7. Leo Jones & Richard Alexander. (1996). *New International Business English*. Cambridge University Press.
8. Christopher Turk & John Kirkman.(1989). *Effective Writing; Improving Scientific, Technical and Business Communication.* 2nd Ed., London: Taylor & Francis Ltd.
9. L.J. Gurak & J.M. Lannon (2010). *Strategies for Technical Communication in the Workplace.* 2nd Ed.,New York: Pearson Education, Inc.
10. M. Monippally. (2001). *Business Communication Strategies*. Tata McGraw Hill.
11. V.R. Narayanaswami (2005). *Strengthen Your Writing*, 3rd ed. Hyderabad: Orient Longman Pvt. Ltd.

Course Outcome:

Learners will be able to:

CO1	Communicate to multiple professional audiences clearly and effectively through both written and verbal modes
CO2	Identify weaknesses in their own writing and apply appropriate revision processes to strengthen communication
CO3	Analyse rhetorical aspects of audience, purpose, and context to communicate technical information effectively in written, oral, and visual media.
CO4	Recognize structures or genres typically used in science and engineering, understand the processes that produce them, and the organizational and stylistic conventions characteristic of them, and apply this knowledge to their own writing tasks.

Mapping of Course Outcome with Programme Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1							✓	✓	✓	✓	✓	✓
CO2							✓	✓	✓	✓	✓	✓
CO3							✓	✓	✓	✓	✓	✓
CO4							✓	✓	✓	✓	✓	✓

EN 631 INSTRUMENTATION AND CONTROL IN ENERGY SYSTEMS

L	T	P	C
3	0	0	3

Course Objectives:

This course is proposed to study about instrumentation and control technics used in energy systems

Course Content

Measurement Errors - Materials, radiant storage- Transducer classification- Static and dynamic characteristics of transducers, Transient analysis of a control system.

Temperature Measurement - Bimaterials, Pressure thermometers, Thermocouples, RTD,Thermisters, and Pyrometry, pyrometers- Calibration of Pressure measuring equipment.

Flow Measurement- Variable head flow meters- Rota meters, Electromagnetic flow meters,Hot wire anemometers, Hot film transducers, Ultrasonic flow meters.

Moving Iron/coil, Energy measurement, power factor meter-Analog signal conditioning, Amplifiers, Instrumentation amplifier, A/D and D/A converters.

Digital data processing and display, Computer data processing and control, Feedback control system, Stability and transient analysis of control systems, Application of PID controllers, General purpose control devices and controller design

Text and Reference Books:

1. A. K. Sawhney. PuneetSawney: A course in Mechanical Measurements and Instrumentation.DhanpatRai&Co 2002
2. Bechwith. Marangoni.Lienhard: Mechanical Measurements Fifth edition. Addison-Wesley 2000
3. J.P. Holman: Experimental methods for engineers Sixth edition, McGraw-Hill .1994

Course Outcome:

CO1	To become familiar with temperature, and pressure measurement systems.
CO2	To become familiar with flow and energy measurement systems
CO3	To become familiar with digital data processing, display and control principles

Mapping of Course Outcome with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO2		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓

ME 657 – SAFETY IN ENGINEERING INDUSTRY

L	T	P	C
3	0	0	3

Course objective:

This course is proposed to give an idea on safety in metal working machinery and wood working machines, principles of machine guarding, safety in welding and gas cutting, safety in cold forming and hot working of metals and safety in finishing, inspection and testing

Course content:

SAFETY IN METAL WORKING MACHINERY AND WOOD WORKING MACHINES General safety rules, principles, maintenance, Inspections of turning machines, boring machines, milling machine, planning machine and grinding machines, CNC machines, Wood working machinery, types, safety principles, electrical guards, work area, material handling, inspection, standards and codes- saws, types, hazards.

PRINCIPLES OF MACHINE GUARDING Guarding during maintenance, Zero Mechanical State (ZMS), Definition, Policy for ZMS – guarding of hazards - point of operation protective devices, machine guarding, types, fixed guard, interlock guard, automatic guard, trip guard, electron eye, positional control guard, fixed guard fencing- guard construction- guard opening.Selection and suitability: lathe-drilling-boring-milling-grinding-shaping-sawing-shearingpresses- forge hammer-flywheels-shafts-couplings-gears-sprockets wheels and chains-pulleys and belts-authorized entry to hazardous installations-benefits of good guarding systems.

SAFETY IN WELDING AND GAS CUTTING Gas welding and oxygen cutting, resistances welding, arc welding and cutting, common hazards, personal protective equipment, training, safety precautions in brazing, soldering and metalizing – explosive welding, selection, care and maintenance of the associated equipment and instruments – safety in generation, distribution and handling of industrial gases-colour coding – flashback arrestor – leak detection-pipe line safety-storage and handling of gas cylinders.

SAFETY IN COLD FORMING AND HOT WORKING OF METALS Cold working, power presses, point of operation safe guarding, auxiliary mechanisms, feeding and cutting mechanism, hand or foot-operated presses, power press electric controls, power press set up and die removal, inspection and maintenance-metal sheers-press brakes. Hot working safety in forging, hot rolling mill operation, safe guards in hot rolling mills – hot bending of pipes, hazards and control measures. Safety in gas furnace operation, cupola, crucibles, ovens, foundry health hazards, work environment, material handling in foundries, foundry production cleaning and finishing foundry processes.

SAFETY IN FINISHING, INSPECTION AND TESTING Heat treatment operations, electro plating, paint shops, sand and shot blasting, safety in inspection and testing, dynamic balancing, hydro testing, valves, boiler drums and headers, pressure vessels, air leak test, steam testing, safety in radiography, personal monitoring devices, radiation hazards, engineering and administrative controls, Indian Boilers Regulation.

Text and Reference books:

1. "Accident Prevention Manual" – NSC, Chicago, 1982.
2. "Occupational safety Manual" BHEL, Trichy, 1988.
3. "Safety Management by John V. Grimaldi and Rollin H. Simonds, All India Travelers Book seller, New Delhi, 1989.
4. "Safety in Industry" N.V. Krishnan JaicoPublishery House, 1996.
5. Indian Boiler acts and Regulations, Government of India.
6. Safety in the use of wood working machines, HMSO, UK 1992.
7. Health and Safety in welding and Allied processes, welding Institute, UK, High Tech. Publishing Ltd., London, 1989.

Course Outcome:

CO1	To become familiar with safety in metal working machinery and wood working machines
CO2	To become familiar with principles of machine guarding, safety in welding and gas cutting
CO3	To become familiar with safety in cold forming and hot working of metals and safety in finishing, inspection and testing

Mapping of Course Outcome with Programme Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO2		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
CO3		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓

HS601 HUMAN RESOURCE MANAGEMENT

L	T	P	C
3	0	0	3

Course Objectives:
This course intends to give an eye opener for the students about Human Resource Management and its functions to develop the efficiency and effectiveness of the Human Resources in an industrial organization.

Course Content:
Human Resource Management- Definition – Features – Importance – Objective of Human Resource Management- Concepts- Commodity, Production, Goodwill, Humanitarian, Human Relations Concepts- Approaches to the Study of Human Resource Management- Systems, Situational, Role, Process approaches- Human Resources Accounting- Case Studies.

Job Design- Approach to Job Design- Engineering, Human, The Job characteristics, Approaches- Job Design Process- Job Design Methods; Job Rotation, Job Enlargement- Job Enrichment- Job Evaluation- Methods of Job Evaluation- Performance Appraisal Methods- Case Studies.

Human Resource Planning- Benefits- Problems- Retention Plan- Organizing Human Resource Planning- Recruitment Policy- Sources of Recruitment- Selection- Meaning- Definition- Need for Scientific Selection Systems- Selection Process- Types of Psychological Tests- Placement- Induction- Employee Training- objectives, Training Process- Methods of Training- Case studies.

Contemporary Problems of HRM- Quality of Work Life- Specific Issues in Quality Work Life (QWL) – QWL and Productivity- Barriers to Quality of Work Life- Strategies for Improvement in QWL- Quality Circles- Definition- Objectives- Processes- Techniques- Organization Structure- Worker's participation in Management- Methods of Worker's participation in Management- Morale and Productivity- Case Studies.

Industrial Relations- Concepts, Structures and Functions- Trade Unions- Unionization- Law and Environment- Collective Bargaining- Concept- Process- Trends and Conclusions- Employee Grievances- Approaches- Procedures- Industrial Conflict- Nature of Conflict- Statutory, Non-Statutory and other Statutory Measures- Case Studies.

TEXT BOOKS:

1. Rao V.S.P, Rao Subbha P, *Personnel/ Human Resource Management-Texts*, Cases and Games- Konark Publishers Pvt. Ltd, 2008.
2. Decenzo A. David, Robbins P. Stephen, *Personnel/ Human Resource Management*-PHI-2012.
3. Monappa Arun, Nambudiri Ranjeet, Patturaja Selvaraj, *Industrial Relations and Labour Laws*, TMH- 2012.
4. Srivastava S.C., *Industrial Relations and Labour Laws*, Vikash Publishing House Pvt. Ltd.-2012.
5. Pareek Udai, Rao T.V., *Designing and managing Human Resource Systems*, Oxford and IBH- 2005.

Course Outcome:

CO1	This course immensely benefits the stake holders to demystify about how the companies create a competent Human Resource Functions to solve bystander, shotgun and capricious personalities pertinent to potential employees.

Mapping of Course Outcome with Programme Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1							✓	✓	✓	✓	✓	✓