SYLLABUS OF MASTER OF TECHNOLOGY IN INSTRUMENTATION AND ELECTRONICS ENGINEERING

First Semester

Category: Departmental / Specialization Basket

PAPER-I

PG / IEE / T / 111A - Measurement System Design
Basic physical laws to sensor modelling. Approach to design build up from specification. Design criteria at component level. Mathematical tools used in design (approach and applicability)- conformal mapping, Laplace transform, Fourier transform, Numerical analysis, Optimization tools. Performance analysis- Root locus, Bode etc to component design. Statistical analysis of system output, bond graph, multi-parameter techniques, regression analysis. Noise performance analysis.

PG / IEE / T / 111B - Process Control System Design/ Synthesis
Process Modeling : Reasons for modeling, Lumped parameter system models, Analytical approximation, Effect of parameter variation, The parameter estimation technique—Linear regression, least square regression technique. Process Dynamics: Different process control parameters, Characteristic parameters of process plant(Self Regulation, Potential value, Process reaction rate, Process resistance, Process Capacitance, Process time lag). Design of process control system following various approaches: Self operating Controller, Pneumatic controller, Electronic Controller, Supervisory controller, Adaptive Controller, Direct Digital Controller, Programmable Logic Controller, Distributed Control Systems. Dynamic model of chemical processes: Balance Equations, Material balance,material and energy balance, Form of Dynamic models—Linear models and deviation variables.Case Study: Gas surge Drum, Isothermal chemical reactor, Jacketed stirred-tank heater.

PG / IEE / T / 111C - Embedded Systems
Pre-requisites: Typical Processor Architecture, Design of Microprocessors / Microcontroller Based Systems, Introductory level knowledge in Operating System.
Introduction to Embedded Systems - definitions and constraints. Processors, Memory organization, Devices and Buses for Device Networks, Device Drivers, Interrupt Servicing Mechanism. Review of typical Software Architectures, Introduction to Real-Time Operating Systems. Hardware-Software co-design approach. Case Studies

PAPER-II

PG / IEE / T/ 112A - Signals and Systems
System representation: Discrete time systems, General definition of a system, SISO & MIMO systems, Math model, State space representation, State-variable model, LTI state equations. Signal Characterization: Deterministic & random signals, General form,

models and specifications, discrete signal representation. Discrete signal and system representation. Deterministic Discrete signal analysis: Discrete Fourier transforms (DFT): Periodic and aperiodic signal analysis, limitations of DFT, Fast Fourier Transforms, Transform equivalence: Z, DTFT, CTFT, FS, DFT. DFT for long sequences, STFT. Practical aspects of DFT. Application of DFT: Filter banks. Stability analysis, Response of a stable system, marginal and asymptotic stability. Random Discrete signal and systems: Mathematical description of random signals, pseudorandom signals, stochastic processes. Brief review of probability. Spectral representation and analysis of non-stationary signals, random signals. Linear systems to random input. Parametric representation of Stochastic processes. Basic concept of processing random signals

PG / IEE / T/ 112B - Computer Simulation in Modeling and Analysis

Nature of simulation; Systems, Models and simulation; Discrete-event simulation; Simulation of queuing and inventory systems; Modeling complex systems; Simulation languages - GPSS-V and SLAM; Comparison with general purpose languages; Selection of input probability distribution; Random number and random variety generators; Output data analysis; Validation of simulation models.

PG / IEE / T/ 112C- Digital Communication System

Digital representation of signals:- Linear, optimum and non-uniform quantization. Adaptive PCM, differential PCM (DPCM), adaptive DPCM (ADPCM). Speech coding, picture signal encoding. Optimum Detection and parameter estimation:- Weighted probabilities and hypothesis testing. Matched filter receiver. Detection of Radar signals. Parameter estimation in communication signals. Estimation of continuous waveforms. Error correcting codes:- Block codes. Binary cyclic codes, multiple error correcting codes, convolutional codes burst-error correcting codes. Two-dimensional codes. Automatic request (ARQ). Information theory:- Information and entropy. Source encoding, noiseless coding .Shannon's first and second fundamental theorems. Markov sources. Channel capacity theorem. Spread spectrum systems:- Direct sequence and frequency hopped spread spectrum signals; their generation and applications .Synchronization of spread spectrum systems.

PAPER-III

PG / IEE / T/ 113A - Advanced Electronic Instrumentation

Statistics, Noise Processes and Error Analysis. Analog to Digital and Digital to Analog Converters: Basic converter errors, D/A converter circuits, A/D conversion principles – integrating, sigma-delta, flash and successive approximation type. Signal Processing Techniques: averaging, integrating, basic filtering techniques, fast Fourier transforms. Grounding and Shielding Techniques: Capacitive and Inductive crosstalk, EM coupling and interference, grounding considerations, shielding theory and techniques. Digital Test & Measuring Instruments: Principle of operation, basic functional blocks and hardware-software issues of the following:

Digital Storage Oscilloscopes

Arbitrary Waveform Generators

Spectrum Analyzers

PG / IEE / T/ 113B - Digital Systems Design with FPGAs

Hierarchy in Design, Controllers, Mealy and Moore Machines, metastability, synchronization, FSM issues, clock trees, clock skew, pipelining, multiple clock domains, case studies. VHDL: behavioral, data flow, structural models, simulation cycles, process, concurrent and sequential statements, loops, delay models, synthesis, FSM coding, library, packages, functions, procedures, resource sharing, test benches, hardware-software cosimulation, bus function models. FPGA: logic block architecture, routing architecture, programmable interconnections, design flow, Xilinx, Vertex and Actel ProASIC architectures, device programming, debugging, applications, case study, embedded system on programmable chips.

PG / IEE / T/ 113C - Medical Instrumentation

General introduction of medical instrumentation, its problems and specialty. Sensing devices for biomedical instruments: general requirements and special considerations.
Equipment standards and patient safety. Diagnostic equipment: vector cardiograph, echocardiograph, comparison of ECG, VCG and ECHO, monitoring and transmission of ECG, IR imaging and its diagnostic criteria, Measurement of blood flow - electromagnetic flow meters and its specialty, plethysmography - impedance plethysmography, discussion of other blood flow meters, their advantages and disadvantages over these methods, Ultrasonography - principles, different scanning modes, its instrumentation. Clinical instrumentation - body fluid content determination, bio-analytical sensors and its uses. Assistive devices: hearing aid and its problems, contact lens and its problems, artificial heart and its viability. Therapeutic devices: chemotherapy.

Category: Inter-Disciplinary Basket

PAPER-IV

PG / IEE / T/ 114A- Soft Computing- Theory and Application

Introduction to soft computing and its constituents. Introduction to fuzzy sets and its importance in real life. Definition, basic operators, T-norm, S-norm, other aggregation operators. Fuzzy relation, implications, cylindrical extension, projection and composition. Approximate reasoning, compositional rule of inference, rule based system, term set, fuzzification, reasoning, defuzzification, different fuzzy models (MA/TS) - some applications of fuzzy rule based system. Introduction to artificial neural networks, basic models like Hopfield networks, multilayer perceptron and learning vector quantization networks, self-organizing feature maps - their properties and applications. Basics of Genetic Algorithms (GA) and its applications. Some hybrid (neuro-fuzzy, fuzzy-neural and fuzzy-GA) systems.

PG / IEE / T/ 114B- Non-Destructive Testing

Surface feature inspection and testing: General, Visual, Chemical, and Mechanical. Optical - laser probe, holography, and ultrasonic surface wave probing, Magnetic -

magnetization, flux, and Electro potential, Electrical resistivity, Electromagnetic - eddy current techniques, Penetrant, Radiation backscatter, etc.
Sub - surface (Internal feature inspection and Testing: Thermal - temperature sensing, Electrical resistivity, ultrasonic - longitudinal and shear wave methods, acoustic emission methods, X rays - refraction / diffraction and fluorescence, Gamma rays - radiography. IQI (image quality indicator), Xerography, Image intensification methods, Electron microscopic techniques. ISO specifications and other certifications.

Alternately, any one subject from the inter-disciplinary basket of ETCE Department.

PAPER-V

PG / IEE / T/ 115A- Calibration and Standardization Practices
Units: Fundamental and Derived Units. Standards: Primary, Secondary and Tertiary standards. Standardizations and Technique: Standardizations of Electrical (voltage, current, frequency, RLC and others), Mechanical (mass, displacement, velocity, acceleration, torque, flow, level, temperature, pressure etc.) and other parameters. Realization in standard laboratories, maintenance and reproduction, test and review. Modern techniques, standards in different National Laboratories and Bureaus. The fundamental constants and their classes and recent evaluation of the fundamental constant. Standardization in Production Plants and manufacturing houses. Reliability studies and inspection, Product Standardization techniques. Calibration: Calibration of measuring Instruments, Theory and Principles (absolute and secondary or comparison method), Setup, Modeling. Sensor calibration and testing. Analytical methods in calibrating.

PG / IEE / T/ 115B- Instrumentation and Measurement Techniques
1. General measurement systems: specifications of instruments, their static and dynamic characteristics
2. Transducers: sensing elements and measurements:
A. Transducers:
Resistance type - potentiometer, strain gauge;
Inductive type – LVDT
B. Sensing elements:
Temperature sensing elements – RTD, thermistor, thermocouple, semiconductor IC sensors;
Pressure sensing elements – manometers, elastic elements, Bourdon tube, diaphragm, bellows, electrical type, McLeod gauge, Pirani gauge;
Flow sensing type – head meters (orifice, venturi), area meters, rotameters, electromagnetic flowmeter, Coriolis flow meter, Ultrasonic flowmeter;
Analytical sensors – pH measurement
C. Measurement circuits:
Deflection bridge, Instrumentation amplifier
3. Principles of Process control:
A. Process control: process systems block diagram, transfer function, stability criteria

B. Types of control: Proportional, Proportional- Integral (PI), Proportional-Derivative (PD), PID
C. Control elements: controller, final control elements, control systems
D. Introduction to PLC and DCS
4. Signal Conditioning:
Switching devices – relays (electromagnetic), contactor, transistor switches
Opamp – inverting, non-inverting, differential configurations
Power amplification, active filters (LP, HP, BP and Notch), constant current and voltage sources.
Wired signal transmission in industry (voltage 1-5V, current 4-20mA loop), F-V, V-F converters, V-I, I-V converters, A/D and D/A converters.

PG / IEE / T/ 115C- Aerospace Instrumentation

Atmospheric Instrumentation: Measurement of pressure static, average, dynamic, impact pressure and total pressure. Measurement of flow direction - probes, impact plate, angle of attack sensors, Measurement of temperature - total temperature of flowing gas, temperature of oxygen, temperature of solid objects.
Measurement of atmospheric density and conductivity, balloons and payloads, electrostatic flux meter. Measurement of pollutants by laser optical method, measurement of NO and ozone, ion density measurement, measurement of stratospheric aerosols, instruments in upper atmosphere studies, measurement using rockets & satellites, measurement of X-ray & X-ray fluxes, optical remote sensing.
Aircraft instrumentation, measurement of aircraft speed, measurement of fluid velocity, local linear velocity & bulk velocity strain and thrust measurement, acceleration, aircraft rocket-study instrumentation, missile control instrumentation, instrumentation in space research.

PAPER-VI

PG / IEE / T / 116A- Mathematical Methods in Instrumentation

Series: Infinite series, Power series; Review of linear ordinary (integer order) differential equations; Fractional order differential equations; Linear systems: Qualitative behaviour; Stability studies; Study of equilibria: Another approach; Nonlinear vis-a-vis linear systems; Stability aspects: Liapunov's direct method; Manifolds: Introduction and applications in nonlinearity studies; Periodicity: Orbits, limit cycles, Poincare map; Bifurcations; Catastrophes; Dynamical systems

PG / IEE / T / 116B- Optimization Techniques

Inadequacy of classical optimization techniques. Linear programming problem, simplex method and extensions. Non-linear programming: Quasi-Newton reduced gradient and gradient projection method. Penalty function methods. Benchmark problems, case studies and computer programs for comparative study of NLP algorithms. Decomposition techniques for large problems. Introduction to dynamic optimization.

PG / IEE / T / 116C- Electro-Optics and Optoelectronics

Polarization, polarizers, dichroism, birefringence, optical activity, induced optical effects – Kerr effect, Pockel effect. Interference, interferometers – wave front splitting, Amplitude splitting, single and multiplayer films Diffraction- Fresnel, Fraunhofer, Rayleigh limit. Spatial light modulators-mirrors, lenses, prisms, Kerr cells, Pockel cells, CCD: basic principle of operation, imaging devices. Optoelectronics: sources - LED, optical detectors, their characterization. Opto-isolators: their characteristics, advantages and limitations. Lasers-theory, types, characteristics. Fiber Optics – basic characteristics, sensors – basic principle and operational details. Holography: principles, holographic recording and readout devices, its application. Optical signal processing – Fourier optics, optical applications

Category: Sessional Courses

SESSIONAL 1

PG / IEE / S / 111- Laboratory
Each student has to be proficient in the usage of certain software tools like MATLAB, PSpice, LABVIEW etc. for use in system modeling, testing and specific instrumentation applications.

SESSIONAL 2

PG / IEE / S / 112- Assignment

Second Semester

Category: Departmental / Specialization Basket

PAPER-VII

PG / IEE / T/ 127A- Instrumental Analysis
Absorption Spectroscopy: Quantitative aspects, photometer and spectrophotometer designs. Molecular UV and V absorption Spectroscopy, Absorbing Species, Application in qualitative and quantitative analysis, Photo acoustic spectroscopy. Molecular fluorescence, phosphorescence and chemiluminescence spectroscopy. Atomic spectroscopy, Atomic absorption types, Atomic fluorescence types. Emission spectroscopy with Plasma, Arc, Spark, Flame emission type. IR absorption spectroscopy-qualitative and quantitative analysis, IR emission spectroscopy. Raman spectroscopy - various types of the spectroscopy and their applications, NMR - application to Proton and other isotopes, environmental effects, ESR. X-ray spectroscopy, fluorescence, absorption, diffraction. The electron microscope. Electron spectroscopy and its applications. Mass spectroscopy - identification of pure compounds, Molecular secondary ion mass spectrometry. Chromatography : Plate theory, qualitative and quantitative analysis, Computerized system; Gas-liquid chromatography, Gas solid type, HPLC, Partition Chromatography, Absorption chromatography, Ion-exchange chromatography, Size exclusion chromatography, Superficial type. Planer chromatography : Thin layer, paper

and Electro chromatography. Electron Microscopy - SEM with auxiliary equipment like AUGER. Electrochemical cells, cell potentials, electrode potentials, Reference electrodes, Metallic electrodes, Membrane electrodes, Potentiometric methods.

PG / IEE / T/ 127B- Sensors- Science and Technology

Principles of Physical and Chemical Sensors: Sensor classification, Sensing mechanism of Mechanical, Electrical, Thermal, Magnetic, Optical, Chemical and Biological Sensors.
Sensor Characterisation and Calibration: Study of Static and Dynamic Characteristics, Sensor reliability, aging test, failure mechanisms and their evaluation and stability study.
Sensor Modeling: Numerical modeling techniques, Model equations, Different effects on modeling (Mechanical, Electrical, Thermal, Magnetic, Optical, Chemical and Biological) and examples of modeling.
Sensor Design and Packaging: Partitioning, Layout, technology constraints, scaling, compatibility study.
Sensor Technology: Thick and thin films fabrication process, Micro machining, IOC (Integrated Optical circuit) fabrication process, Ceramic material fabrication process, Wire bonding, and Packaging.
Sensor Interfaces: Signal processing, Multi sensor signal processing, Smart Sensors, Interface Systems.
Sensor Applications: Process Engineering, Medical Diagnostic and Patient monitoring, Environmental monitoring etc

PG / IEE / T/ 127C- Control of Industrial Process

Basics of process control systems, process instrumentation diagram for different process control loops.
Instrumentation system design for different units:-

- Deaerator of power plant
- Safety Interlock instrumentation system of a turbine driven boiler feed water pump.
- Control of Distillation Column
- Control of Furnace

Process Plant Instrumentation: Ammonia Production in a Fertilizer, Instrumentation System Design for Carbon, Sulphur and Hydrogen Sulphide gas removal process.
Studies of different Units related to process plant: Annunciator, Transmitter
Comparative study of PLC, DCS and SCADA.

PAPER-VIII

PG / IEE / T/ 128A - Speech Processing

Introduction to speech processing - its necessity. Digital models for speech signals: process of speech production, acoustic theory of speech production, and models of speech production, auditory knowledge. Digital representation of speech waveform: sampling speech signals, quantization, delta modulation, differential PCM, code conversion, other new methods of coding. Fundamentals of speech analysis: background of speech processing tools, spectrographic analysis, short time analysis, time frequency analysis,

homomorphic analysis. Linear predictive coding of speech: basic principles, solutions of LPC equations, prediction error, application of LPC parameters. Fundamentals of speech recognition: current state of speech recognition systems, techniques and problems for noisy speech recognition, statistical and speech model based methods. Speech enhancement: spectral subtraction, noise masking, and comb filtering, statistical modeling.

PG / IEE / T/ 128B - Digital filtering and Control

Classical Random Signal analysis: Estimation concept, Maximum likelihood estimation, covariance estimation, nonparametric methods of spectral estimation, coherence analysis. Modern Random Signal analysis: All pole estimation, All zero estimation, Pole-zero estimation, Spectral estimation. Parametric signal processing: optimal estimation, filters Adaptive signal processing: Adaptation algorithms, All zero adaptive filters, Pole-zero adaptive filters. Adaptive estimation Model based signal processing: State space filters, Kalman filter identifier, Kalman filter deconvolver. Estimation for nonlinear dynamic systems. Duality in control and filtering

PG / IEE / T/ 128C - Pattern Recognition

Introduction to three facets of pattern recognition: clustering, classification and feature analysis. Supervised learning, unsupervised learning. Bayesian classification, nearest neighbour classification, linear and quadratic discriminant functions, support vector machines. Linkage, k-means and ISODATA clustering techniques. Introduction to feature extraction, selection and ranking. Fuzzy sets, its relevance to pattern recognition. Fuzzy c-means clustering algorithms and fuzzy rule based classification. Motivation for neuro-computing, discussions on Hopfield networks, multilayer perceptron and learning vector quantization networks in relation to pattern recognition.

PG / IEE / T/ 128D - Advanced Microprocessors and Microcontrollers

Intel 8086 (16-bit): Architecture, addressing modes, instruction set, assembler and cross-assembler, input-output, system design using 8086. Intel 80386 and upgrades (32-bit): Basic programming model, addressing modes, instruction set, memory and I/O management, math coprocessor, upgrades of the 80386. A typical 16-bit microcontroller with RISC architecture and integrated A-D converter e.g. PIC18Cxxx family: advantages of Harvard architecture, instruction pipeline, analog input, PWM output, serial I/O, timers, in-circuit and self programmability. Instruction set. Typical application. Development tools.

PAPER-IX

PG / IEE / T/ 129A- MEMS Sensors and Actuators

Design: Methodology of MEMS Design- Flow chart. Components – Modelling, Design, Fabrication, packaging, material characterization VLSI technology used in Micro-sensor system. Application:

Sensors: Inertial sensors, acoustic devices, RF MEMS, pressure sensors, chemical sensors, biochemical sensors.
Actuators: Electrostatic, thermal, electromechanical, others.

PG / IEE / T/ 129B- Electronic System Design

Signal Conditioning, Instrumentation and isolation amplifiers, analog filters, analog switches. Signal measurement in the presence of noise: synchronous detection, signal averaging. Noise in electronic systems: design of low noise circuits. Interfacing of analog and digital circuits. Programmable circuits, architecture of a typical FPGA and its application. Case studies. A/D and D/A conversion: sampling and quantization, antialiasing and smoothening filters. Switched capacitor circuits and applications.

PG / IEE / T/ 129C- Electronic Olfaction

Introduction to human olfaction: Nasal chemosensory detection, Thresholds for odour and nasal pungency, Psychometric functions for odour and nasal pungency, The linear salvation model and its application to odour and nasal pungency. Olfactometry – Static and dynamic, Environmental Chambers, Instruments for chemical sensing. Odour handling and delivery system: Physics of evaporation, Sample flow system, Headspace sampling, Diffusion method, Permeation method, Bubbler, Sampling Bag method, Preconcentrator. Sensors for olfaction: Survey and classification of chemosensors, Chemoresistors, MOS, Organic conducting polymers, Chemocapacitors, QCM, SAW, Optical odour sensors. Signal conditioning and pre-processing: Bridge circuits, amplifiers, Filters, Linearizers, Baseline manipulation, Normalization, Noise in sensors and circuits. Pattern recognition methods: Nature of sensor array data, Classification of analysis techniques. Statistical pattern analysis methods – Linear discriminant analysis, principal component analysis, Cluster analysis. Intelligent pattern analysis methods – Multilayer feedforward networks, Competitive feature mapping networks, Fuzzy based pattern analysis, Neuro fuzzy systems.

Category: Inter-Disciplinary Basket

PAPER-X

PG / IEE / T/ 1210A- Dynamic System Control and Optimization

Mathematical descriptions of linear systems- input-output and state space descriptions Time varying, time-invariant and dicrete-time systems. Nonlinear systems – local linearization. Modelling and Identification. Controllability, Observability, Gramians, Lyapunov stability ; Optimization - Performance Index. State Feedback and State Estimators. MIMO systems, RGA Analysis, Multi time-scale systems. MIMO Feedback control – stability, decoupling, Asymptotic Tracking, Disturbance Rejection. Robust Stability and Performance. Performance limitations for MIMO systems; Fault diagnosis and fault-tolerant systems.

PG / IEE / T/ 1210B - Control System Synthesis

A. Principles of Statistical Design:
Power density spectra of system outputs, mean square error minimization, optimum system in time domain; optimization/minimization in servo problems, Saturation control, Nonlinear Systems.
B. Nonlinear Systems:
a. Describing Function: System design using describing function techniques, limitations and disadvantages, accuracy analysis.
b. Phase plane technique: Construction, interpretation, limit cycles, types of non-linear elements, optimization methods.
C. Digital Control:
a. Discretization - requirement, principles and methods.
b. Design Methods - Root locus, frequency response etc., their limitations; Different approaches of digital controller design - by transformation of continuous time model to z-domain, by direct digital modelling, by discrete approximation, by transformation to w-domain. Algorithm design - direct method, parallel method, factorization method; General Design considerations, Comparison of algorithms.
D. State variable approach to Control System Design, Design of non-interacting controllers, Introduction to Optimal Control, State estimation, Controllability, Observability, Kalman algorithm and its variants.
E. Large Scale Systems: System decomposition, Hierarchical, Multilevel Control and their co-ordination.
F. Control designs using distributed computer network.

PG / IEE / T/ 1210C - Environmental Instrumentation
General introduction to pollution and its classification. Air pollution: its effect on environment, its classification, meteorological factors responsible for pollution, method of sampling and measurement. Air pollution control methods and equipment: basics of fluid properties, cleaning of gaseous effluents, particulate emission equipments and control, particulate collector selection and gaseous emission control. Specific gaseous pollutants analysis and control. Water pollution: its sources and classification, wastewater sampling and analysis, wastewater treatment. Solid waste management and Hazardous waste management. Sound pollution: basics of sound pollution, its effect to environment. Acoustic noise measurement, monitoring and control.

PG / IEE / T/ 1210D- Applied Fractional Order Systems
Mathematical Basis: Definition of Fractional Order Differential Equation (FODE) and Fractional Order Integration Equation (FOIE), difference between FODE and Integer order differential equation, computational difficulties in FODE and FOIE, effect of initial conditions. Developing efficient numerical tools. Fractional Order systems in physical world: Mechanical systems- visco-elastic, thermal; Chemical systems- diffusion, corrosion, micro-porous; Electrical systems -magnetic, dielectric relaxation; Application of Factional Order Systems: Modeling of physical systems, Fractional PID controller design, Optimal Controller design, Signal processing.

Category: Sessional Courses

SESSIONAL 1

PG / IEE / S / 121- Term paper leading to thesis

SESSIONAL 2

PG / IEE / S / 122- Seminar

Third and Fourth Semester

Category: Sessional Courses

SESSIONAL 1

PG / IEE / TH / 21- Thesis Work

SESSIONAL 2

PG / IEE / VV/ 22- Viva-Voce