DEPARTMENT OF APPLIED PHYSICS
UNIVERSITY COLLEGE OF TECHNOLOGY
UNIVERSITY OF CALCUTTA

Course structure for Semester system
M. Tech. Degree in Instrumentation & Control Engineering
w. e. f. the academic year 2017-18

Semester I Examination

Theoretical

PAPER NO.	SUBJECT	PERIODS			EVALUATION SCHEME				CREDITS
		L	T	P	TA	CT	ESE	TOTAL	
MIT11	Computational Methods	4			20	10	70	100	4
MIT12	Modern Control Systems	4			20	10	70	100	4
MIT13	Biomedical Measurement and Instrumentation	4			20	10	70	100	4
MIT14	Elective Paper I	4			20	10	70	100	4

Practical

PAPER NO.	SUBJECT	PERIODS			EVALUATION SCHEME				CREDITS
		L	T	P	TA	CT	ESE	TOTAL	
MIP11	Advanced Control Lab	-	1	7	50		50	100	4
MIP12	Biomedical data acquisition and processing Lab	-	1	7	50		50	100	4

Semester II Examination

Theoretical

PAPER NO.	SUBJECT	PERIODS			EVALUATION SCHEME				CREDITS
		L	T	P	TA	CT	ESE	TOTAL	
MIT21	Advanced Control Systems	4			20	10	70	100	4
MIT22	Advanced Digital Signal Processing	4			20	10	70	100	4
MIT23	Advanced Process control	4			20	10	70	100	4
MIT24	Elective Paper II	4			20	10	70	100	4

Practical

PAPER NO.	SUBJECT	PERIODS			EVALUATION SCHEME				CREDITS
		L	T	P	TA	CT	ESE	TOTAL	
MIP21	Advanced process control Lab	-	1	7	50		50	100	4
MIP22	Term Paper leading toward Thesis	-	2	6	50		50	100	4

Semester III Examination

PAPER NO.	SUBJECT	PERIODS			EVALUATION SCHEME				CREDITS
		L	T	P	TA	CT	ESE	TOTAL	
MIP31	Seminar	-	2	6	50	-	50	100	4
MIP32	Project Phase I	-	4	12	50	-	150	200	8
MIP33	General Viva Voce	-	-	-	-	-	-	100	4

Semester IV Examination

PAPER NO.	SUBJECT	PERIODS			EVALUATION SCHEME				CREDITS
		L	T	P	TA	CT	ESE	TOTAL	
MIP41	Project Phase II	-	8	24	100	-	300	400	16

DETAILED SYLLABUS
M. Tech. Degree in Instrumentation & Control Engineering
w. e. f. the academic year 2019-20

SEMESTER I

MIT11	**Computational Methods**
	Wavelet Techniques: Introduction to Wavelet Transform and its application in signal processing. Fuzzy Sets: Classical sets and fuzzy sets, fuzzy sets and probability, fuzzy numbers, operations and properties, membership functions and its types. Fuzzy inference mechanism, fuzzy rule base and reasoning – linguistic variables, concept of approximate reasoning. Engineering examples. Artificial Neural Network (ANN): Neuron model – Biological neuron, artificial neuron, activation function, mathematical model. ANN architecture – feed-forward network, single layer and multi layer, Back-propagation learning mechanism in ANN. Introduction to random processes and stochastic systems: Probability and random variables, statistical properties of random variables, linear system models of random processes and sequences, orthogonality principle, introduction to Kalman filter and its application
MIT12	**Modern Control Systems**
	Review of classical feedback controls: Stability margins, correlation of frequency domain and time domain parameters, 2 DOF PID controllers and their design specifications, Compensator design. **State Space:** Control Systems Analysis and Design in State Space: Basics of State Space modeling, State Transition Matrix, Tests for controllability and observability for continuous time systems – Time varying case, time invariant case. Effect of state feedback on controllability and observability, Design of State Feedback Control through Pole placement. Cayley–Hamilton theorem, minimal polynomial, Lagrange−Sylvester interpolation. Introduction to Optimal Control, Kalman algorithm and its variants, **Digital Control Systems:** Concepts of linear sampled data systems: Sampling Theorem, Discrete equivalents of continuous data systems, Reconstruction of sampled signals, sample and holds processes, Review of Z transform and Inverse transforms, Pulse transfer function, stability of linear sampled data systems. Concept of Z-domain stability, S-plane to Z-plane mapping, Routh stability criteria, Schur-Cohn criterion, Jury's stability test. Structure of a computer controlled system. Computation of time response of Discrete Data system. Bilinear Transformation. Sampled data version of PID controllers. **Introduction to nonlinear and time varying systems:** Difference between Time Invariant and Time Varying systems, Forced and autonomous systems, Equilibrium state and equilibrium point, Norms of Signals and Systems, Stability of equilibrium state, Definition of nonlinear systems, Difference between linear and nonlinear systems, Properties of nonlinear systems, Stability and instability in the sense of Lyapunov. **Linearization Techniques:** Linearization by small signal analysis (Taylor series expansion), linearization by nonlinear feedback and linearization by inverse nonlinearity, and Conditional stability analysis.
MIT13	**Biomedical Measurement and Instrumentation**
	General Introduction to biomedical Instrumentation and special considerations. Action potentials in living cells, Electrodes and their models, Electrophysiology of the heart and cardiovascular system, ECG its measurement protocols and instrumentation; measurement of Brain and muscle activities: EEG and EMG; Safety in Biomedical Instrumentation and standards.

	Measurement of Blood flow and Blood pressure: Measurement of respiration, GSR, Plethysmography: Impedance and photoplethysmogram; cardiac output. Biomedical devices: Defibrillator and pacemakers. Instrumentation in clinical laboratory: measurement of pH, ESR, oxygen, Hb in blood Biomedical imaging techniques: Ultrasonograph, CT Scan, PET, magnetic resonance imaging, Patient monitoring systems, biotelemetry.
MIT14	**Elective Paper I [Any one from the list]**
PRACTICAL	
MIP11	**Advanced Control Lab**
MIP12	**Biomedical data acquisition and processing Lab**

SEMESTER II

MIT21	**Advanced Control Systems**
	Robust Control Systems: Introduction to robustness, Representing uncertainty, parametric uncertainty, Representing uncertainty in the frequency domain, SISO robust stability, SISO robust performance, Examples of parametric uncertainty, Structured and Unstructured uncertainty. Internal Stability, Stability robustness and Performance robustness of Control Systems, Mu-Synthesis, H2 and H-infinity Control and Loop Shaping. Linear Matrix Inequalities (LMI). **Nonlinear Control systems Analysis and design:** Common physical nonlinearities. Modeling of nonlinear physical systems. **Phase Plane Analysis:** Phase plane method - basic concept, trajectories, phase portrait, singular points and their classification, limit cycle and behavior of limit cycle, jump resonance, Phase plane analysis of nonlinear systems, Construction of phase trajectories. **Describing Function Analysis** (DF): Derivation of general DF, DF for different nonlinearities, and Stability analysis of nonlinear system: Prediction of stability of nonlinear systems using DF method, Relay, Dead-zone, Backlash, and Saturation. Frequency domain stability criteria, Popov's method and is extensions. **Lyapunov Stability Analysis:** Concept of asymptotic stability, Concept of sign definiteness, quadratic form of scalar functions, Sylvester's theorem, Lyapunov stability theorems, stability analysis of linear and nonlinear systems, and construction of Lyapunov functions by Krasovskii method, variable gradient method. **Adaptive control systems**: Introduction to Adaptive Control, Block Diagram of an Adaptive System, Effects of Process Variations on System Performance, Types of Adaptive Schemes, Linear parametric models, Adaptive laws, Model reference adaptive control, Robustness in adaptive control, Adaptive control of nonlinear systems, Gain scheduling control Model Reference Adaptive System (MRAS), The MIT Rule, Block Diagram of an MRAS for adjustment of Feed Forward Gain based on MIT Rule. Adaptation Gain – Methods for determination. Design of MRAS using Lyapunov Theory – Block Diagram of an MRAS based on Lyapunov Theory for a System. **Internal model principle based control:** Internal model principle, Repetitive Control, Finite Dimensional Repetitive Control, Robust Repetitive Control, Resonance Control, Modified Resonance Control
MIT22	**Advanced Digital Signal Processing**
	Brief introduction to digital signal processing, Review of Z transform, Fourier Transform, Discrete Fourier Transform and applications Digital processing of continuous-time signals; Digital filters: approximations, transformations, IIR

	and FIR filters, FIR filter design, window method, frequency sampling method, Realization structure for FIR filters, FIR implementation techniques; Design of IIR filters : impulse invariant method, bilinear transformation method of coefficient calculation; Realization structure for IIR filters, IIR implementation techniques, Analysis of finite word length effects in fixed point digital signal processing. Introduction to adaptive filters and its applications, Stochastic process, FIR Weiner Filter, Steepest decent technique, LMS algorithm, Convergence analysis, Introduction to optimal filter design. Data adaptive methods for signal reconstruction and filtering – Wavelet and Empirical Mode Decomposition based techniques and applications.
MIT23	**Advanced Process control**
	Idea of 'good control', Controller performance index, Model based and model free tuning and their comparative study, Advanced tuning techniques, direct synthesis. Model based control, model uncertainty and disturbances, IMC structure and design, IMC based PI-PID controller design. Introduction to multi-variable control systems, interaction analysis and multiple single loop design, design of multivariable controllers, relative gain array, tuning of MIMO systems, concept of de-coupler design. Fuzzy control technique and its structure, Fuzzy control- real time expert system design, Knowledge based controller design, non-linear fuzzy control, Inferencing schemes, Rule base generation and rule minimization techniques. Adaptive fuzzy control, Performance monitoring and evaluation, Adaptation mechanism. Neural controller design, Neural-fuzzy controller with hybrid structure, Neural-fuzzy adaptive learning control network, structure learning of Neural-fuzzy controller. Optimization techniques of Fuzzy and Neural-fuzzy controllers.
MIT24	**Elective Paper II [Any one from the list]**
PRACTICAL	
MIP21	**Advanced process control Lab**
MIP22	**Term Paper leading towards Thesis**

OPTIONAL PAPER I

MIO11	**Advanced Engineering Mathematics**
	Nonlinear differential equations: graphical and analytical methods of solutions; Perturbation and variation of parameter methods; Ritz and Galerkin method; Riccati, vander Pol, Duffing.Matheu equations; Approximate solution of integral equations; Nonlinear integral equation;Operation research and quality control: Estimation of parameters, testing of hypothesis,decisions; Quality control, acceptance, sampling, non-parametric tests, fitting of straight lines; operational research Fourier Transform: Fourier integrals and its interpretation, Fourier transformation, Frequency spectrum, Linear transformation of vector spaces; sum and scalar multiplication, product, polynomial and invertible transformations; matrix representation of linear transformation; Solution of linear equations;. Eigen values and eigen vectors, matrix polynomial; Cayley-Hamilton theorem and its application; computation of matrix functions. Canonical representations: Jordan and rational canonical form; bilinear, quadratic and Hermitian forms, positive and negative definite and semi definite form, Sylvester's criteria.
MIO12	**Instrumentation and Measurement Techniques**
	Transducers: sensing elements and measurements: Measurement of displacement, velocity and acceleration: Variable Inductance and variable capacitance transducers, Seismic accelerometers- piezoelectric and piezoresistive types. 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 flow meter, Coriolis flow meter, Ultrasonic flow meter; Smart Sensors, Introduction to Microelectromechanica Systems(MEMS) , Tomographic Techniques : Capacitance and Impedance. Principles of Process control: process systems block diagram, transfer function, stability criteria. Types of control: Proportional, Proportional- Integral (PI), Proportional-Derivative (PD), PID; Control elements: controller, final control elements. 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.
MIO13	**PC based Instruments**
	PC based DAS: functional structure and layout; Signal conditioning fundamentals: amplification, single ended or differential inputs, isolation, Noise reduction techniques: Grounding, Shielding, Filtering etc, linearization, excitation. Principles of data acquisition in a PC: sampling concepts, AD converters and their characteristics, Bus protocols, PC expansion buses: ISA, EISA and PCI bus; Data acqusition using serial interfaces: RS-232,RS-422 and RS-485, USB; Plug-in data acquisition boards, Introduction to Virtual Instrumentation, Graphical programming techniques, distributed VI. Instrumentation buses: IEEE 488.1 and IEEE 488.2, PCMCIA, VXI, SCXI, PXI. Introduction to NI LabVIEW: Functional blocks and capabilities; practical interfacing of real life sensors with VI: Thermocouple, Thermistor etc.
MIO14	**DC and AC Machines**
	DC Machines: Building up of voltage of shunt generator, parallel operations of dc generators; DC motors: starting and speed control, testing of generators and motors. **Polyphase induction machine:** Rigorous analysis, high torque motors, harmonic torque, Schrage motor. Induction generators, parallel operation. **Synchronous machine**: principle of operation, regulation of synchronous machine, Parallel operations: Torque-load angle characteristic, Steady state stability: Synchronous machines connected to bus system, operational chart, load sharing , self oscillation. requirements, conditions; Synchronous motor, uses. Synchronous condenser: steady state operation, uses, excitation systems. Special transformer: Group connection, Scott, V-V, Earthing transformer, Pulse transformer; Welding transformer, their operation and uses.
MIO15	**Power Plant instrumentation**
	Role of instrumentation, Instrument layout, Instrument schedule Instrument test pocket; Desk panel layout. control room layout; Burner management system auto control loops; Drum level control, Mill air flow and outlet temperature control Superheated steam temperature control; Instrument wiring diagram; Transmitter grouping annunciation system; SCADA system; Plant performance and outage.
MIO16	**Process Automation**
	Programmable logic controller, Distributed Control system, Field control system, SCADA, Smart and Intelligent sensors, controllers and transmitters, Types Of Communication Interface, Types Of Networking Channels, Parallel and serial communication Interface, Communication Mode, Synchronization And Timing In Communication, Standard Interface, Software Protocol, ASCII Protocol, HART Protocol, Manufacturer Specific Protocol, Network Topology, Media Access Methods, Open System Interconnection (OSI) Network Model, Device Bus and Process Bus Network, Controller Area Network (CAN), Devicenet, Controlnet, Ethernet, Proprietory Network, Smart Distributed System, Interbus – S, Seriplex Bit-Wide Device Bus Network, AS-I Interface, General Structure Of An Automated Process
MIO17	**Artificial Intelligence and Robotics**
	Problem solving methods: Control strategies, Heuristic search, Reasoning, Breadth, depth and best search; Knowledge representation, Predicate Logic, Non monotonic reasoning, statistical

	and probabilistic reasoning, Semantic nets, Conceptual dependency; AI languages, Important characteristics. Expert system: structure, interaction with experts, Design examples; Origin and types, Degree of freedom, Asimov's law, Dynamic stabilization; Power sources, and sensors,: Hydraulic, pneumatic, and electric drives, mechanical design, electrical speed control, path determination; Machine vision, ranging, Manipulators, Actuators and Grippers: constructions, dynamics and force control. design consideration; Kinematics and path planning, Solution of inverse kinematics problem; work envelop, hill climbing technique, Robot programming languages; Applications.

OPTIONAL PAPER II

MIO21	**Biomedical Signal Processing and Analysis**
	Objectives and difficulties in biomedical signal processing and analysis; Details of biomedical Signals - ECG, EEG and respiration signals and their spectral properties, Signal pattern in normal and different abnormal conditions. Noise and artifacts in biosignals and its effect in diagnosis; Methods for noise elimination by conventional filtering and adaptive techniques Detection of events - Time domain analysis of biosignals, Frequency domain analysis of biosignals – Basics of Fourier Transform, Wavelet Transform and their applications in biosignal processing Diagnostic decision making – feature extraction, feature selection, classification techniques Introduction to analysis of non- stationary and multi-component signals
MIO22	**Sustainable Power Generation And Supply**
	Different forms of sustainable power sources : Solar, biogas, wind, tidal, geothermal Basic bio-conversion mechanism, mechanism of generation of electricity, isolated operation and operation of the system with grid. Wind and tidal energy generation; special characteristics, turbine parameters and optimum operation, Ocean thermal energy conversion, Geothermal energy- hotsprings and steam injection, power plant based on Wind, Tidal, OTEC and geothermal springs, operation of such plants with grid Energy from the sun : Fundamentals of the technology, increase of efficiency, study of nano-structures, supply of power to Grid. limitation of photovoltaics efficiency. Fuel cells, peak load demands, developments in fuel cells and applications. Direct energy conversion methods : Photoelectric, thermo-electric, thermionic, MHD (magnetohydrodynamics) and electro chemical devices, photovoltaic and solar cells. Fusion energy : Controlled fusion of hydrogen, helium etc. Energy release rates, present status and problems, future possibilities. Integrated energy packages using solar, biomass, wind. Comparative study of non-conventional energy sources, cost considerations and economics.
MIO23	**Precision Instruments 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 Calibration: Calibration of measuring Instruments, Theory and Principles (absolute and secondary or comparison method. Special types of CROs- analog storage, digital storage, sampling oscilloscope, mixed oscilloscope, spectrum analyser, harmonic distortion analyser, modulation analyser, arbitrary

	function generator. Advance Bridge methods, Ratio Measurements, Inductive voltage divider, Ac and DC current comparator, Voltage comparator, DC Current transformer, Low flux Measurements, saturable reactor techniques in measurements, Magnetic modulator, Flux Gate Magnetometer.
MIO24	**Special Electrical Machines**
	Special Machines : Reluctance Motor, Switched Reluctance Motor, Brushless DC motor, Hysteresis motor, servomotor, stepper motor, PCB motor. Electronic excitation schemes for these. PM synchronous motor and generator. 1-phase alternator, linear induction motors. Energy efficient motor. Induction Regulators: Basic Principles. Study of the doubly-fed slip-ring machine and the induction generator for synchronisation to the grid. Microcontroller DSP and PLC application to motor drives. Introduction to AI application to Machine drives. Feedback system components like tachogenerators, optical encoders, Hall-effect sensors.
MIO25	**Hazardous Area and Control Room Instrumentation**
	Concept of safe area and hazardous area, Hazardous area classification, Protection techniques, Material classification, Methods of explosion prevention-encapsulation; pressurization; purging; immersion; alarms and interlock, Explosion suppression system, Suppression techniques and suppression chemicals, Explosive actuated rupture disc, Deluge system, Intrinsic safety, Classification of Intrinsic safety, Intrinsically safe loop, Safety barrier and their classifications, Enclosure classifications, Fuses and Circuit breakers, Flame arrester, Conservation vents, Emergency vents, Dessicating vents, Fire and smoke detector, Flame scanner and Flame sensors. Control room definition and location, Control room instruments, Reliability principles and assessments, Building high-reliability systems, Control room panel type and panel layout, Panel piping and tubing, Panel wiring and termination, EM Interference, Shock hazard protection, Isolation, Different types of ground, Single point grounding, Multi point grounding, Bonding, Filtering, Shielding, Cable laying and distribution, Human engineering- Man-Machine interface system, Characteristics of man, Information capability, Priority settings, Information coding, Operator load, Control room environment, Indicators and display items, Characteristics of light sources, Push button and switches, Power distribution, Battery backup, UPS, System redundancy.
MIO26	**Pollution control and process plant instrumentation**
	Identification of sources of pollution, effect of pollution, sampling, measurement and analysis of pollutants in air, water and soil, Control of pollution; Instrumentation practice in process plant: functions, responsibility, economic considerations, wiring diagram, panel based design consideration and pollution control; Instrumentation system for typical process industries: fertilizer, petrochemical, distillation, drying, food processing, pulp and paper .
MIO27	Machine Learning Techniques
	Basics of ML and brief history, AI, ML vs AI, ML vs Deep Learning, Types of ML; General Steps of ML Supervised Learning- Classification: Random Forest, Decision Trees, Logistic Regression, Support Vector Machines, KNN, Naïve Bayes Regression: Linear Regression, Regularization Techniques ,Polynomial Regression Unsupervised Learning Clustering : K-Means, K Nearest Neighbors, Association Rule Learning Dimensionality Reduction: PCA, SVD Reinforcement Learning: Markov Decision, Monte Carlo Prediction Neural Networks/Deep Learning :CNN, RNN/LSTM/GRU, Transfer Learning Predictive Analytics - Forecasting: Logistic, Time Series (ARIMA), Case Study (Time Series) Ensemble Techniques: Boosting, Bagging