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 2014-15

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	Biomedical Measurement and Instrumentation	4			20	10	70	100	4
MIT13	Embedded Systems	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 Measurement and Biomedical Instrumentation Lab	-	1	7	50		50	100	4
MIP12	Embedded Systems 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	Data Communication & Industrial Networking	4			20	10	70	100	4
MIT22	Advanced Process control	4			20	10	70	100	4
MIT23	Advanced Digital Signal Processing	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	Communication Lab	-	1	7	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 2014-15

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. Optimization Techniques: Classification of optimization problems, classical optimization techniques. Evolutionary algorithms-GA and PSO and their operators. Ideas of other stochastic algorithms like ACO, HS, GSA etc. Engineering examples.
MIT12	**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.
MIT13	**Embedded Systems**
	Microcontroller based system: Introduction to Intel 8051 MCU architecture, addressing modes, structure of internal RAM, handling of ports, timer and counters, interrupt structure, serial communication, programming using assembly and C language. PIC Microcontroller family with hardware details, handling of peripherals – ADC, timer and counter, SPI, I2C, external memory interfacing, PWM and compare modes. DSP processor based system: The components of DSP core, peripherals and interfaces, registers, memory, interrupts. FPGA based system: Overview of Field Programmable Gate Arrays- CPLD, FPGA. Types of FPGA, basic components. Overview of Spartan 3E FPGA board with some case studies. RTOS: Real time specifications, real time kernels, AVR based systems, inter-task communications and synchronizations.
MIT14	**Elective Paper I [Any one from the list]**
PRACTICAL	
MIP11	**Advanced Measurement and Biomedical Instrumentation Lab**
MIP12	**Embedded Systems Lab**

SEMESTER II

MIT21	**Data Communication & Industrial Networking:**
	Digital representation of signals:- Linear, optimum and non-uniform quantization. Adaptive PCM, differential PCM (DPCM), adaptive DPCM (ADPCM). Speech coding, picture signal encoding. Error correcting codes:- Block codes. Binary cyclic codes, multiple error correcting codes. Information theory:- Information and entropy. Source encoding, noiseless coding .Shannon's first and second fundamental theorems. Channel capacity theorem. Spread spectrum systems:- Direct sequence and frequency hopped spread spectrum signals; their generation and applications .Synchronization of spread spectrum systems. Process automation networking- communication hierarchy, process bus network, device bus network, classification of I/O bus networks, networking at I/O and field levels. Industrial communication network- models and features, complete and reduced OSI models and their significance, different communication modes, various MAC mechanisms and their comparison. Protocols- definition and architecture, data framing, serial communication standards and protocols, MODBUS,Profibus, HART, wireless HART. Fieldbus- evolution and architecture, traditional vs. fieldbus, topologies, concept of DART, fieldbus wiring-terminators-hubs etc.
MIT22	**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.
MIT23	**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.
MIT24	**Elective Paper II [Any one from the list]**

PRACTICAL	
MIP21	**Advanced process control Lab**
MIP22	**Communication Lab**

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	**Advanced Control theory :**
	Power density spectra of system outputs, mean square error minimization, optimum system in time domain; optimization/minimization in servo problems, Saturation control, Nonlinear Systems : Describing Function: System design using describing function techniques, limitations and disadvantages, accuracy analysis. Phase plane technique: Construction, interpretation, limit cycles, types of non-linear elements, optimization methods. Digital Control: Discretization - requirement, principles and methods. 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. 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.
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	**Microwave principles and Measurements**
	Microwave technique of communication ; Microwave generator ; Klystron, Magnetron, and Travelling wave tube; Cavity: Natural modes of oscillation in rectangular and cylindrical cavity, Condition of maximum amplification; Maser and parametric amplifiers; Microwave accessories: Antenna Characteristics, Dipole antenna, Radiation pattern , Directivity, Gain, Linear Array, Microwave measurements, Power, VSWR Impedance, Wave length, Q of resonance cavity, Dielectric constant measurement.
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	**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.