DEPARTMENT OF APPLIED PHYSICS
UNIVERSITY COLLEGE OF TECHNOLOGY
UNIVERSITY OF CALCUTTA

Regulation for 2 year 4 semester M. Tech. course in Instrumentation & Control Engineering w. e. f. the academic year 2014-15

1. Department of Applied Physics, University College of Technology, University of Calcutta shall provide instructions leading towards the 2-year, 4-semester M. Tech. degree in **Instrumentation & Control Engineering**. The course is of two (2) years duration comprised of four (4) Semesters, each Semester being of six (6) months' duration.
2. A candidate, who has passed the 3-year B. Tech. degree in Instrumentation & Control Engineering from University of Calcutta or its equivalent degree from any other university or institute approved by All India Council for Technical Education (AICTE), will be eligible to apply for admission to the 4-Semester Master of Technology (M. Tech.) course in **Instrumentation & Control Engineering** of University of Calcutta.
3. The award of the said M. Tech. Degree in **Instrumentation & Control Engineering** will be conferred to students who are successful in all of the four (4) Semester examinations. End-Semester Examination (ESE) **and a**t least one class test will be held for each theoretical paper in each Semester. End-semester examination will be held for each practical paper in each Semester. The schedule of both theoretical and practical papers and distribution of marks and credit for the said four (4) Semesters are given in course structure.
4. Four (4) lecture hours per week shall be allotted to each theoretical paper of 100 marks and four (7) practical hours and one (1) tutorial hour per week shall be allotted to each practical paper of 100 marks in a laboratory. For seminar papers of 100 marks six (6) practical hours and two (2) tutorial hours per week shall be allotted. For project phase –I paper of 200 marks twelve (12) practical hours and four (4) tutorial hours per week shall be allotted. For project phase –II paper of 400 marks twenty four (24) practical hours and eight (8) tutorial hours per week shall be allotted. However, for general viva-voce paper no contact hour will be provided.
5. A candidate shall be eligible for appearing at any of the Semester examinations provided, he/she prosecutes a regular course of studies in the Department of Applied Physics maintaining the minimum percentage of attendance as specified by the University.
6. (a) Each theoretical paper of 100 marks shall be comprised of 20 marks for Teacher-Assessment (TA), 10 marks for Class Test (CT) , and 70 marks in End Semester Examination (ESE). TA and CT put together will form the sessional component of the total marks in any theoretical paper.

(b) Teacher-Assessment will be divided ordinarily into three components – attendance, group discussion and performance. Marks for each class test will be awarded by conducting at least one (1) test.

(c) Duration of ESE for each theoretical paper shall be of three (3) hours. For each theoretical paper there shall ordinarily be two (2) internal paper setters. Each theoretical paper shall be examined by the internal examiners.

(d) Each practical paper shall be of 100 marks, out of which 50 marks is assigned for Teacher Assessment (TA) to be assessed by the internal examiner(s) on the basis of performance in the laboratory and records of experiments and 50 marks for ESE. For 50 marks of ESE for each practical paper, an assessment will be made through a representative practical test and viva-voce, which shall ordinarily be made by a board of examiners consisting of at least two (2) members.

7. (a) On the basis of total marks (TA+CT+ESE) secured in each paper, **Grade (G)** and **Grade Point (GP)** shall be awarded to a student.

The equivalence between grades, grade points and the percentage marks is given by:

Percentage (%) of marks	Grade (G)	Grade Point (GP)
≥ 90	E	10
89 – 80	A	9
79 – 70	B	8
69 – 60	C	7
59 – 50	D	6
< 50	F	0

(b) Each paper shall carry **Credit (C)** according to the number of hours allotted per week and as indicated in the following table:

Paper	No. of hours / week	Credit (C) assigned
Theoretical	1	1
Tutorial	1	0.5*
Practical	1	0.5*

*: For fractional credit, calculation is to be made by rounding off.

(c) In the course structure, the credits assigned to each semester is as follows:

Semester	Credit
1	24
2	24
3	16
4	16
TOTAL	80

(d) In any paper, a candidate securing a grade higher than `F`, that is, Grade Point greater than zero, will be eligible to earn `credit` assigned to that paper. In other words, if a student is unable to secure a grade higher than 'F', that is, grade point greater than zero, he / she fails to earn any 'credit' assigned to that paper.

(e) The performance of a candidate in n^{th} (n = 1,2,3,4) Semester examination, who earns all the credits of that semester, will be assessed by the '**Semester Grade Point Average' (SGPA), 'S_n'** to be computed as:

$$SGPA\,[S_n] = \frac{\sum_k [C_k\, GP_k]}{\sum_k C_k}$$

where 'k' denotes the number of papers in a particular semester

and $\sum_k C_k$ denotes the total credits of a particular semester and GP_k is the grade point of k^{th}. paper.

(f) On completion of the M. Tech. course, the overall performance of a candidate will be assessed by the '**Cumulative Grade Point Average' (CGPA),** to be computed as:

$$CGPA = \frac{\sum_{n=1}^{4} [C_n\, S_n]}{\sum_{n=1}^{4} C_n}$$

where, $C_n = \sum_k c_k$ and $\sum_{n=1}^{4} C_n$ denotes total credits of all the semesters i.e. 80 credits.

8(a) Each candidate shall opt two (2) elective papers of 100 marks each, one in 1^{st} and another in 2^{nd} semester, from the list of elective papers to be notified in respective semesters. Such topics of elective papers may be revised from time to time as per recommendation of the Board of PG studies in Applied Physics.

(b) Each candidate shall have to submit a report on a seminar work of 100 marks assigned to him/her under the guidance of a faculty member(s) of the Department during 3^{rd} semester examination. He / she has to defend his/her seminar report in an open session. The assessment of this report shall be made by a board consisting of at least three (3) examiners of whom at least one (1) shall be external.

(c) (i) Each candidate shall execute a Project work assigned to him/her during the 3rd and 4th Semester courses under faculty member(s) of the Department and he/she has to submit a report on the same at least 5 (five) days before the date of examination. The project is divided into two phases. Project Phase-I of 200 marks is assigned during 3rd semester while Project Phase-II of 400 marks is assigned during 4th semester. The candidate has to present and defend his/her project work in an open session, which shall include internal and external examiners.

Out of the 200 marks assigned to Project Phase-I, 50 marks is earmarked for Sessional work to be assessed by the internal supervisor(s), 150 marks for the presentation of the project and viva voce on the project work. Out of the 400 marks assigned to Project Phase-II, 100 marks is earmarked for Sessional Work to be assessed by the internal supervisor(s), 300 marks for the presentation of the project and viva voce on the

project work. The assessment of the presentation of the project and project viva voce shall be done by a board consisting of at least five (5) examiners of whom ordinarily two (2) shall be external examiners.
(ii) A candidate may also carry out his/her project work under joint guidance of faculty member(s) of the Department and a competent person from any industry/academic institution subject to the approval of Departmental Committee. He/she may carry out his/her project work either in the department or in the concerned industry/academic institute.
(e) The general viva-voce test for 100 marks shall be conducted during 3rd Semester examination, by a board consisting of at least five(5) examiners. Two (2) of the board members shall be external examiners.

9. Candidates appearing in a semester examination shall join classes in the next semester immediately, wherever applicable, after completion of the examination.

10. Candidates of 1st to 3rd Semester examinations will be allowed to continue in the next semester provided he/she secures at least the following credits respectively and for the 4th Semester, he/she has to secure the following credit:

Semester	Minimum Credit to be obtained
1	16
2	16
3	16
4	16

11. A candidate earning less than the credits mentioned in **clause number 10** in any semester will be declared as **'unsuccessful'** candidate in that semester examination. He/she will have to take readmission in the corresponding semester in the next academic session as per CU rules and he/she will be allowed two (2) such consecutive chances to earn the **minimum credit**.

12. (a) The shortfall in credits, being termed as **'due credit'** (the candidate being unsuccessful in one or more papers) of a semester will have to be earned by the candidate by appearing in the said paper(s) at the examination of the corresponding semester in the next academic session and he/she will have two (2) such consecutive chances to earn his/her **due credit.**
(b) If he/she fails to earn the due credit within permissible chances (**as per clause 12(a))**, he/she will be declared as '**failed**' candidate. In such a case he/she will have to take readmission in the first semester class as per CU rules.

13. (a) For a candidate, who fails to earn all the '**credit**' of a semester but continues to the next semester by virtue of earning minimum credit **(clause number 10),** it is necessary that, total accumulation of shortfall in credit carried by the candidate, must not exceed 12 (twelve) at any stage, and in such a case **he/she shall not be allowed to continue the course any further.**
(b) In order to complete the M. Tech. course, a candidate will have to utilize all the allowed chances within four (4) years from the date of first admission. A candidate who fails to earn all the credits of the M. Tech. course within the permissible chances **will not be allowed to continue the course any further**.
(c) If a candidate is unable to appear at any of the theory or practical examination(s), he/she will earn zero (0) credit in that paper(s).

14. The CU syndicate shall publish a list of successful candidates of the M. Tech. examination for each of the Semester examinations.
15. At the end of each Semester examination, a Grade-Sheet showing the Semester performance (Semester Grade-Sheet) indicated by **SGPA** will be issued to the students. However, SGPA will not be calculated for those candidates who fail to earn all the credit in that Semester.
The Semester Grade Sheet should have the following basic information:

Paper	Details of course	Full Marks	Marks obtained	Credit	Grade	Grade Point	SGPA	Remarks

16. (a) A consolidated Grade-Sheet, showing the overall performance in the M. Tech course indicated by **CGPA**, will be issued only to those successful students who have earned 80 (eighty) credit in the M. Tech. course.
The consolidated Grade-Sheet shall consist of two components. The first component will contain the information of the 4th Semester itself as follows:

Paper	Details of courses	Full Marks	Marks obtained	Credit	Grade	Grade Point	SGPA	Remarks

And the second component will contain a **summary** of all the semesters having the following basic information:

<table>
<tr><td rowspan="3">Semester</td><td rowspan="3">Total credit</td><td rowspan="3">Credit obtained</td><td rowspan="3">Back credit</td><td rowspan="3">SGPA</td><td rowspan="3">Full marks</td><td rowspan="3">Marks obtained</td><td colspan="2">Cumulative statement</td></tr>
<tr><td>Total credit</td><td>80</td></tr>
<tr><td>CGPA</td><td></td></tr>
<tr><td>4</td><td>16</td><td></td><td></td><td></td><td>400</td><td></td><td rowspan="2">Total Full marks</td><td rowspan="2">2000</td></tr>
<tr><td>3</td><td>16</td><td></td><td></td><td></td><td>400</td><td></td></tr>
<tr><td>2</td><td>24</td><td></td><td></td><td></td><td>600</td><td></td><td>Marks obtained</td><td></td></tr>
<tr><td>1</td><td>24</td><td></td><td></td><td></td><td>600</td><td></td><td>Result</td><td>*</td></tr>
</table>

The asterisks (*) in the last row of the last column will contain the information regarding the final achievement of the candidate in all the examinations. This box will contain only one of the following three information:
'1st Class' / '2nd Class' / 'Failed'.
(b) Candidates securing at least 66 (sixty six) percent of the total marks in M. Tech. Examination (total of semester 1 to semester 4 examinations) shall be placed in the 'First Class' and those securing 50 (fifty) percent marks or more but less than 66 (sixty six) percent marks shall be placed in the 'Second Class'. Candidates securing less than 50 (fifty) percent shall be declared 'Failed'.

17. The Degree of '**Master of Technology in Instrumentation & Control Engineering'** from the Department of Applied Physics under the seal of the University shall be awarded to a successful candidate mentioning the grade and class he/she has obtained.

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.