Curriculum Postgraduate Programme

Master of Technology

in

CONTROL AND INSTRUMENTATION ENGINEERING

DEPT OF INSTRUMENTATION AND CONTROL ENGINEERING

Batch: 2014-16, 2015-17, 2016-18

Dr B R AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY

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ABOUT NITJ

Dr B. R. Ambedkar National Institute of Technology Jalandhar was established in the year 1987 as Regional Engineering College and was given the status of National Institute of Technology (Deemed University) by the Government of India on October 17, 2002 under the aegis of Ministry of Human Resource Development, New Delhi. Now the Ministry of Human Resource Development, Government of India has declared the Institute as —Institute of National Importance under the act of Parliament-2007. The Institute has been placed amongst top 50 engineering institutions of the country as per the survey conducted by Mint-C Fore in the year 2008. The survey was based upon vital parameters, such as curriculum, quality of academic input, students care, admission procedure, infrastructure, placements and overall goodwill of the Institute. A large number of reputed Industrial houses in the country visit the Institution and select the final year students as Engineers/ Management Trainees. As one of the National Institutes of Technology (NIT), the Institute has the responsibility of providing high quality education in Engineering, Technology and Sciences to produce competent technical and scientific manpower for the country. The Institute offers B Tech, M Tech, M Sc & Ph D programmes in the several disciplines of engineering, technology and Sciences.

Vision

To build a rich intellectual potential embedded with interdisciplinary knowledge, human values and professional ethics among the youth, aspirant of becoming engineers and technologists, so that they contribute to society and create a niche for a successful career.

Mission

To become a leading and unique institution of higher learning, offering state-of-the-art education, research and training in engineering and technology to students who are able and eager to become change agents for the industrial and economic progress of the nation. To nurture and sustain an academic ambience conducive to the development and growth of committed professionals for sustainable development of the nation and to accomplish its integration into the global economy.

Department of Instrumentation & Control Engineering

The Department of Instrumentation and Control Engineering commenced its Bachelor of Technology (B. Tech) degree programme in 1990. Initially, the degrees were awarded by Guru Nanak Dev University Amritsar, subsequently, the Institute was affiliated to the newly set-up Punjab Technical University for the period July 1997 through October 2002. The Institute was accorded Deemed University Status w.e.f. October 17, 2002 under the aegis of Ministry of Human Resource Development, New Delhi. Now the Ministry of Human Resource Development, Government of India has declared the Institute as "Institute of National Importance" under the act of Parliament-2007.

Instrumentation and Control Engineering is a well-diversified discipline. Many areas of specialization namely Process Instrumentation, Control Systems, Biomedical Engineering, Robotic, Wireless Networking etc. have grown by leaps and bounds and have emerged as full fledged disciplines in themselves. Training students in all these areas is an uphill and challenging task. Therefore, every effort has been made while developing curricula to ensure full cognizance of all value elements among students. A holistic approach has been adopted while framing curriculum, updating infrastructural facilities and improving coaching methods. The teaching scheme has been enriched by the valuable inputs of experts of respective fields from prestigious institutions / organizations such as IIT Roorkee and IIT Delhi, R&D organizations like CSIO and leading industries of the region.

The Department has commenced M Tech (Full Time) Degree Programme in Control & Instrumentation Engineering w.e.f. July, 2006 and M Tech (Part-Time) Programme w.e.f. July, 2010. The Department has also started Ph D Programme in 2005 in the areas of Instrumentation and Control Engineering, Biomedical Engineering, Robotics and Wireless Networking. The Department is consolidating its efforts to promote industrial research and consultancy in appropriate areas of Instrumentation and Control Engineering. The Department has also one Patent granted to its credit.

Vision

To excel in the field of Instrumentation and Control Engineering education, research and innovation with interdisciplinary approach responsive to the needs of industry and sustainable development of society while emphasizing on human values and professional ethics.

Mission

- To create and disseminate knowledge through research, quality education and creative inquiry.
- To orient the education and research towards latest developments through close interaction with industry, other institutions of higher learning and research organizations.
- To train the students in problem solving and soft skills, inculcating leadership and team-work qualities, human values and ethical professionalism.

PREFACE

With rapidly changing industrial scene and technological advances that have taken place in microelectronics, telecommunications and computer technologies the field of Instrumentation and Control Engineering (ICE) has been revolutionalized. This needs upgradation and updating the existing academic programmes, so that trained human resources are competent to meet requirements of today's industries. Accordingly the Department of Instrumentation and Control Engineering has come forward to restructure the academic programmes stipulated under the credit based system.

It is really challenging to evolve a common programme for this discipline that meets the need of national and international industries and research establishments. However, with the rich experience of successful experimentation with above idea for over forty years, the task of development of a model curriculum could be possible.

The suggested curriculum is based on philosophy presented by the Dean (Academic Programmes) during the Senate meeting of the institute. It possesses the following features:

The suggested curriculum is in conformity with IIT/AICTE norms with emphasis on analysis and design of industrial processes required to work in control environment.

The graduates turned out have to be acceptable by national and international industry and academic / research establishments.

The programme has to be forward looking in context of the rapid changing scenario of science and technology which provides a proper balance in teaching of basic sciences, social sciences and management, engineering sciences and technical arts, technologies and their applications. Core subjects have been selected to cover all those, which are essential in training of ICE graduates.

The curriculum presents flexibility so that new programmes started with reasonable sources can be managed with a scope of further updating as the resource position improves.

The above features have been achieved by offering a number of electives courses both departmental and open in nature.

I take this opportunity to express my deep appreciation to members of the Senate for their valuable suggestions and critical comments in finalizing the curriculum and Professor SK Das, Director, NIT Jalandhar for his initiative and direction. I am also grateful to Dr HK Verma, Ex-Director, IIT Roorkee and Prof. Vinod Kumar, IIT Roorkee for suggesting essential ingredients, which needs to be incorporated. It is hoped that the curriculum complied in form of the booklet will be of immense help to the students and the faculty in smooth offering the under graduate programme in Instrumentation and Control Engineering. I thank all the members of curriculum committee and the faculty of ICE Department for help and cooperation rendered in bringing out this booklet in time.

(Dr S K Pahuja)
Head
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Programme Outcomes (POs)

a) Graduates would have comprehensive technical knowledge with capability to formulate and solve complex problems using modern tools with dexterity in Control and Instrumentation Engineering and related fields.

b) Graduates would have acquired soft skills through presentations, seminar and dissertation.

c) Graduates would have the capability to learn continuously and adapt in the world of constantly evolving technologies.

d) Graduates would have learnt to work ethically for the benefit of the society and environment.

Programme Educational Outcomes (PEOs)

The Programme Educational Objectives of this Programme are:

i) the graduate should become a successful professional (Teacher/ Researcher/ Engineer/ Entrepreneur) having independent project handling capabilities too

ii) the graduate should attain professional competence to continuously adapt to the technological needs of the society

iii) the complete engineer with professional and social ethics inline with human values

Dr B R Ambedkar National Institute of Technology, Jalandhar
Department of Instrumentation and Control Engineering

Proposed Scheme of Teaching and Examination
M. Tech (Control and Instrumentation) for 2014 admissions onwards

Course Code	Subject	Teaching Load			Credit	Exam. Duration	
		L	T	P	C	Theory	Practical
I SEMESTER							
CIX-501	Discrete Control Systems	3	0	0	3	3 hrs.	-
CIX-503	Process Control and Instrumentation	3	0	0	3	3 hrs.	-
CIX-505	Virtual Instrumentation	3	0	0	3	3 hrs.	-
CIX-507	Embedded Systems	3	0	0	3	3 hrs.	-
CIX-5XX	Elective-I	3	0	0	3	3 hrs.	-
CIX-5XX	Elective-II	3	0	0	3	3 hrs.	-
CIX-523	Process Control and Instrumentation Laboratory	0	0	3	2	-	3 hrs.
CIX-525	Virtual Instrumentation Laboratory	0	0	3	2	-	3 hrs.
		18	**0**	**6**	**22**	**18**	**6**
II SEMESTER							
CIX-502	Industrial Automation and Robotics	3	0	0	3	3 hrs.	
CIX-504	Medical Instrumentation	3	0	0	3	3 hrs.	
CIX-506	Soft Computing Techniques	3	0	0	3	3 hrs.	
CIX-5XX	Elective-III	3	0	0	3	3 hrs.	
CIX-5XX	Elective-IV	3	0	0	3	3 hrs.	
CIX-5XX XXX-XXX	Elective-V*	3	0	0	3	3 hrs.	-
CIX-522	Industrial Automation and Robotics Laboratory	0	0	3	2	-	3 hrs.
CIX-524	Medical Instrumentation Laboratory	0	0	3	2	-	3 hrs.
		18	**0**	**6**	**22**	**18**	**6**
III SEMESTER							
CIX-600	Dissertation (Phase-I)	0	0	12	6	-	-
CIX-601	Seminar	0	0	6	3	-	-
		0	**0**	**18**	**9**	**-**	**-**
IV SEMESTER							
CIX-600	Dissertation (Phase-II)	0	0	24	12	-	-
GRAND TOTAL		**36**	**0**	**54**	**65**	**36**	**12**

* In the allotted slot of the time table, the students will have the option to opt for subjects from other departments, if possible.

List of Electives

Sr. No.	Course No.	Course Title
1.	CIX-580	Smart Sensors and Sensor Networking
2.	CIX-581	Advanced Measurement Systems
3.	CIX-582	Robust and Optimal Control
4.	CIX-583	Power Electronics and Drives
5.	CIX-584	Sensor Data Fusion
6.	CIX-585	Data Acquisition and Telemetry
7.	CIX-586	Biomedical Signal Analysis
8.	CIX-587	Identification and Adaptive Control
9.	CIX-588	Physiological Control Systems
10.	CIX-589	Industrial Instrumentation
11.	CIX-590	Human Computer Interfacing
12.	CIX-591	Computer Networks
13.	CIX-592	System Modeling and Reliability
14.	CIX-593	PLC, DCS & SCADA
15.	CIX-594	Analytical Instrumentation
16.	CIX-595	Medical Imaging and Processing
17.	CIX-596	Power System Operation and Control
18.	CIX-597	Power System Planning and Reliability
19.	CIX-598	Power System Reliability

Course Outcomes (COs)-summary of MTech Programme

After completing the course the students:

a) will be having in depth knowledge and problem analysis skills of various courses related to Control and Instrumentation Engineering.
b) will be having exposure of various practical issues related to Control and Instrumentation Engineering.
c) will be having good knowledge of soft skills to analyze the performance of various Control and Instrumentation systems.
d) will learn to make and deliver presentations through seminar activity and will be passing through a process of project/thesis work where they will make design, fabrication and test of the project work and then write a report.
e) will learn to work ethically which is beneficial to the society.

Detailed Course Content of 1ST Semester

CIX-501 Discrete Control Systems [3 0 0 3]

Computer Controlled System: Configuration of the basic digital control scheme, general sampled data system variables, signal classifications, why use digital control system, Advantages, disadvantages, examples of discrete data and digital control systems.
Signal Processing in Digital Control: Sampling process, Frequency domain analysis, ideal samples, Shannon's sampling theorem, generation and solution of process, linear difference equations, data reconstruction process, frequency domain characteristics.
Discrete System Modelling: Determination of the transform, mapping between s and z domains, transform of system equations, open loop Hybrid sampled Data Control Systems, open loop discrete Input Data Control System, closed loop sampled data control system, modified transform method, response between sampling instants, stability on the z-plane and Jury's stability test, steady state error analysis for stable systems.
State Variable Analysis of Digital Control Systems: State descriptions of digital processors, conversion of state variable models to transfer functions, conversion of transfer functions to canonical state variable models, first comparison form, second companion form, Jordon Canonical form, state description of sampled continuous time plants, solution of state difference equations, closed form solution, state transition matrix, Cayley Hamilton Technique, concept of controllability and observability, loss of controllability and observability due to sampling.
Design of Digital Control: Digital PI, PD and PID Controller, Position and velocity forms, state regulator design, design of state observers, dead beat control by state feedback and dead beat

Recommended Books:
1. Kuo BC, "Digital Control Systems," Oxford University Press
2. Ogata K, "Discrete Control Systems," Prentice Hall

Reference Books:
3. Houpis CM and Lamount GB, "Digital Control Systems-Theory, Hardware, Software," McGraw Hill
4. Gopal M, "Digital Control and State Variables Methods," Tata McGraw Hill
5. Deshpande PB and Ash RH, "Computer Process Control," ISA Publication
6. George VI and Kurian CP, "Digital Control Systems," Cengage Learning India
7. Phillips CL and Troy NH, "Digital Control System – Analysis and Design," Prentice Hall

Course Outcome:
The student should be able
- To make mathematical model of digital/sampled data control systems
- Analyze them using various techniques
- Test them for system stability, controllability and observability

CIX-503 Process Control and Instrumentation [3 0 0 3]

Review of Process Control Fundamentals: Process control principles, elements of process control system, process characteristics, control system parameters, control system evaluation, process and instrumentation symbols and diagrams
Transducers and Signal Conditioning: Definition and classification of sensors, working principles and salient features of thermal sensor, optical sensors, displacement and location sensors, strain sensor, level sensor, motion sensor, pressure sensor, flow sensor., principles of analog signal conditioning and design guidelines, passive circuits, operational amplifier circuits in instrumentation,
Controller principles: Principles, applications and examples of discontinuous controller modes, continuous three term controller, cascade control, over-ride control, split range control, feed forward control, ratio control, adaptive, self-adaptive control, optimal control, supervisory and direct-digital control, final control operation: signal conversion, actuators and final control element.
Programmable Logic Controllers: Principles, relative merits over hard-wired logic, relay and programming languages, ladder diagrams.
Distributed Control Systems (DCS): Distributed process control, DCS-configurations, Control console equipment, Video display, Overview display, detail & graphical displays. DCS-control unit, Controller file, Communications between components, DCS-data highways, field buses, multiplexers and remote terminal units, DCS-flow diagrams, generic nature of DCS, Supervisory Control techniques, introduction to SCADA.
Multivariable Control System: Interactions in multiples loops, RGA method for minimizing interactions.

Recommended Books:
1. Stephanopoulos G, "Chemical process control: an introduction to theory and practice," Prentice Hall
2. Bartelt T, “Process control systems and instrumentation,” Cengage Learning

Reference Books:
3. Seborg DE, Edgar TF and Mellichamp DA, "Process dynamics and control," Wiley
4. Smith CA and Corripio AB, "Principles and practice of automatic process control," Wiley
5. Johnson CD, "Process control instrumentation technology," Prentice Hall
6. Liptak GB, “Instrument Engineers' Handbook, vol.2: Process Control and Optimization,” CRC Press

Course Outcome:
On successful completion of this course the student will
- Design, Monitor**,** analyze and control the various process parameters of industrial process.
- Learn state of art control techniques (PLC and SCADA, DCS)

CIX-505 Virtual Instrumentation [3 0 0 3]

Introduction: Definition, comparison with hard wired instruments, VI architecture, block diagram representation, VI application softwares, salient features and application areas.
LabVIEW basics: Introduction, building front panel and block diagram, tools and palettes, creating subVI, Controlling program flow – Loops, structures, shift registers, local and global variables, data types- Numeric, digital, strings, arrays, clusters, waveform, data presentation elements, graphs and charts.
LabVIEW advance: File input – output, timing and synchronization, mathematical analysis function. Data communication functions, programmatically controlling VIs
Data acquisition basics: Classification of signals, analog I/O and digital I/O signal acquisition, study different types of data acquisition system (USB, PCI, RS-485 network based).
LabVIEW data acquisition and instrument control: Study of various functions, Interfacing DAQ system with LabVIEW, Building VIs for analog I/O and digital I/O, study of VIs, control of instruments and DAQ system using serial, RS-485 and GPIB interface.
Software signal processing and manipulation: Sampling theorem, anti-aliasing filters, time and frequency domain analysis, Windowing, signal generation, spectrum analysis, digital filtering.
Case study: Development of VIs for specific application (simulation, real time)

Recommended Books:
1. Wells LK, "LabVIEW for everyone – Graphical Programming made even easier," Prentice Hall
2. Gupta S and Joseph J, "Virtual Instrumentation using LabVIEW," Tata McGraw Hill

Reference Books:
3. Johnson GW, "LabVIEW graphical Programming- Practical application in instrumentation and Control," Tata McGraw-Hill
4. Ritter DJ, "LabVIEW GUI- Essential Techniques," Tata McGraw-Hill
5. National Instruments, "LabVIEW-User Manual," National Instruments Corporation

Course Outcome:
On successful completion of this course the student will be able to:
- Understand the concepts and definition of Virtual Instrumentation, general design model of Virtual Instrumentation system and role of LABVIEW as VI software
- Understand graphical programming concepts of LABVIEW, study / use of basic to advance functions and structure of LABVIEW to build virtual instruments.
- Under concepts and method of data acquisition, signal generation and analysis in LABVIEW to build virtual instruments for real time or simulated applications

CIX-507 Embedded Systems [3 0 0 3]

Introduction & Architecture of 8051 Microcontroller: Review of architecture and instruction set of 8085 microprocessor. Overview of 8051 architecture. CISC & RISC processors.
8051 Instructions: Addressing modes, data transfer arithmetic and logical instructions. Bit instructions, jump, loop and call instructions. Time delay using instructions.
Programming of 8051 Microcontroller: Input/output port programming, Timer/counter programming for different modes. Serial communication and programming for different modes.
Programming of interrupts and priority of interrupts; power down mode programming; programming in C language.
Interfacing to8051 Microcontroller: Interfacing of 7 segment display, LCD and keyboard. Interfacing of DC motor, stepper motor and relay. Interfacing of ADC, DAC and sensors.
Advanced Topics: On board buses for embedded systems-I^2C & SPI; real time tasks and types, real time systems, real time operating systems. Hardware software co-design, embedded product development lifecycle management. Introduction to PIC and ARM microcontrollers.

Recommended Books:
1. Mazidi MA, Mazidi JG and Mchinlay RD, "The 8051 Microcontroller and Embedded Systems using assembly and C," Pearson Education
2. Das LB, "Embedded Systems: An integrated approach," Pearson Education

Reference Books:
3. Morton TD, "Embedded Microcontrollers," Pearson Education
4. Valvano JW, "Embedded Microcomputers Systems: Real Time Interfacing," Cengage Learning India
5. Ram B, "Advanced Microprocessors and Interfacing," Tata McGraw-Hill
6. Rajkamal, "Microcontrollers: Architecture, Programming, Interfacing and System Design," Pearson Education
7. Ray AK and Bhurchavdi KM, "Advanced Microprocessors and Peripherals: Architecture, Programming and Interfacing," Tata McGraw-Hill

Course Outcome:
On successful completion of this course the student will be able to:
- Understand the architecture, hardware, programming and interfacing of the Intel 8051 microcontroller
- Develop microcontroller based systems for real time applications
- Understand the basic concepts of embedded system design and its applications to various fields

CIX-523 Process Control and Instrumentation Laboratory [0 0 3 2]

At least 8 experiments are to be performed out of the following list:

1. To control the level of fluid with the help of ON/OFF control system.
2. To study the control loop of a system of a flow control.
3. To find the differential gap of ON/OFF control system.
4. To rig up an electronic proportional controller unit.
5. To rig up an electronic proportional integrated controller unit.
6. To rig up an electronic PID controller and verify its working.
7. To study the characteristics and controller specifications of different types of control valves and other repair and maintenance.
8. To study and obtain Input/Output relationship of a pneumatic relay.
9. To measure flow using rotameter.
10. To measure temperature using thermocouple, RTD and thermistor.
11. To measure the pH value of given solution.
12. Study of characteristics of various transmitters (electronic/pneumatic/ hydraulic etc.).
13. To study the characteristics of different types of pressure, flow, level gauges

The list of experiments given above is only suggestive. The Instructor may add new experiments as per the requirement of the course.

Course Outcome:
On successful completion of this course the student will be able to:

- Perform different control actions for process stations
- Perform various advance control strategy experiments on process stations
- Perform PLC and SCADA programming using ladder logic and RS View for different process stations

CIX-525 Virtual Instrumentation Laboratory [0 0 3 2]

At least 8 experiments are to be performed out of the following list:

1. Develop a LabVIEW Virtual Instrument to carry out the arithmetic operations on two numbers fed by user and display the result on the front panel.
2. Develop a LabVIEW VI to generate random number and plot it on the uniform chart .The operation is controlled by the user through the ON/OFF switch.
3. Develop a password window to open the front panel of the VI developed in experiment 1.
4. Build a VI that compares two numbers. If they are equal, LED on the front panel turns ON. If they are not, a message box is displayed indicating, which number is greater.
5. Build a VI that displays the temperature value continuously on the uniform chart in red color after one second of time interval when the acquisition is switched on using build-in temperature simulator.
6. Build a VI that uses formula node to evaluate y = sin(x) and graph the result.
7. Build a VI that that takes the average of the 20 temperature vales and displays the result on temperature indicators. Also store the 20 temperature values in the array.
8. Build a VI to plot temperature reading from two simulators on single uniform chart in different colors.
9. Build a VI to save the data generated in experiment 5 in Excel sheet file with each value stamped with date and time.
10. Build a VI to retrieve data stored in experiment 9 in text and graphic mode.
11. Build a VI to read analog input and write analog output to the respective channels of DAQ system.(PCI based, RS-485 based, USB based)
12. Build a VI to switch ON/OFF the LED from the front panel connected to the digital output channel of DAQ system.
13. Build a VI to monitor the input channels of DAQ card.
14. Build a VI to publish live data from one VI to another.
15. Build a VI to use different type of signal analysis functions.

The list of experiments given above is only suggestive. The Instructor may add new experiments as per the requirement of the course.

Course Outcome:
On successful completion of this course the student will be able to:

- Gain knowledge and expertise in LABVIEW programming to build virtual instruments for a given problem
- Understand and use the data acquisition platform to interface analog / digital signal for making a VI system for real time measurement / control applications

Detailed Course Content of 2ND Semester

CIX-502 Industrial Automation and Robotics [3 0 0 3]

Industrial Automation: Introduction to automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations, Automation for Machining Operations, Automated Flow Lines with Storage Buffers, Automation for Material Handling, Conveyor Systems, Automated Guided Vehicle Systems, Automated Storage/Retrieval Systems.
Computer Based Industrial Control: Introduction & Automatic Process Control, Building Blocks of Automation System: LAN, Analog & Digital I/O Modules, SCADA System & RTU. PLC and its applications for automation.
Fundamentals of Robotics: Introduction, classification of Robots, History, Advantages and Disadvantages, components, degree of freedom, joints and coordinates, reference frames, workspace, languages and applications, Introduction to mobile robot mapping and path planning.
Robot Kinematics and Dynamics: Introduction to Forward and inverse kinematics of robots, Denavit-Hertenberg representation of forward kinematics of robot, Calculation of the Jacobian, inverse Jacobian. Lagrangian Mechanics: short overview, dynamic equations for multiple degree of freedom robots.
Actuators: Characteristics of actuating system, Comparison of actuating systems, Hydraulic devices, Pneumatic devices, Electric motors.
Sensors: Sensor characteristics, Position sensors, Velocity sensors, Acceleration sensors, Force and pressure sensors, Torque sensors, micro switches, Light and IR sensors, Touch and tactile sensors, Proximity sensors, Range finder, Voice Recognition devices, Introduction to multisensor data fusion.

Recommended Books:
1. Craig JJ, “Introduction to Robotics: Mechanics and Control,” Prentice Hall
2. Spong MW and Vidyasagar M, “Robot Dynamics and Control,” Wiley

Reference Books:
3. Mittal RK and Nagrath IJ, “Robotics and Control,” Tata McGraw-Hill
4. Amber GH and Amber PS “Anatomy of Automation,” Prentice Hall
5. Viswanandham, “Performance Modeling of Automated Manufacturing Systems” Prentice Hall

Course Outcome:
Understand the concept of computer based industrial automation
- Concept of flexible automation system
- The role of robots and Automated guided vehicles (AGV’s) for process plant
- understand the kinematics, dynamics and design issues of the industrial robots
- understand the control strategies for achieving desired position and orientation of robotic tool point.

CIX-504 Medical Instrumentation [3 0 0 3]

Human Body Subsystems: Brief description of neuronal, muscular, cardiovascular and respiratory systems; their electrical, mechanical and chemical activities.
Cardiovascular System: Measurement of blood pressure, blood flow, cardiac output, cardiac rate, heart sounds; Electrocardiograph, Phonocardiograph, Plethysmograph.
Respiratory System: Measurement of gas volume, flow rate, carbon-dioxide and oxygen concentration in exhaled air.
Electrical activity in Neuromuscular System and Brain: Neuron potential, muscle potential, electromyography, brain potentials, electroencephalograph.
Medical Imaging: Fundamentals of imaging, Computed tomography, MRI, Nuclear Medicine, Single-photon emission computed tomography, PET, Ultrasonography, Electrical Impedance, Tomography.
Medical Safety: Electrical Safety, Electrical safety codes and standards; Radiation safety, Chemical safety, Biological safety, Fire and explosive safety, Environmental Safety.
Assisting and Therapeutic Equipments: Pacemakers, Defibrillators, Ventilators, Nerve and Muscle stimulators, Diathermy, Heart-Lung machine, Infant incubators, Audio meters, Dialyzers.

Recommended Books:
1. Webster JG (Ed.), "Medical Instrumentation, Application and Design," Wiley India
2. Carr JJ and Brown JM, "Introduction to Biomedical Equipment Technology," Pearson Education

Reference Books:
3. Waugh A and Grant A, "Ross and Wilson Anatomy and Physiology in Health and Illness," Elsevier
4. Webster JG (Ed.), "Encyclopedia of Medical Devices and Instrumentation," Vols. 1-4, Wiley
5. Bronzino JD (Ed.), "The Biomedical Engineering Handbook," CRC Press

Course Outcome:
On successful completion of this course the student will be able to:
- Know the human anatomy and physiological signal measurements
- Learn about the techniques used for measurement of Blood flow, blood pressure, respiration rate and body temperature
- Analyze the recording of ECG, EEG, EMG and ERG signals
- Understand the concept of assisting and therapeutic devices

CIX-506 Soft Computing Techniques [3 0 0 3]

Introduction: History of development in neural networks, neural network characteristics, Artificial neural network technology, Model of a neuron, topology, learning, types of learning, supervised, unsupervised and reinforcement learning.
Supervised Learning: Basic hop field model, the perceptron, linear reparability, Basic learning laws, Hebb's rule, Delta rule, Widroff and Huff LMS learning rule, correlation learning rule, In star and out star learning rules. Unsupervised learning, competitive learning, K mean clustering algorithm, Kolwner's feature maps.
Radial Basis Function: Basic learning laws in RBF network, recurrent networks, recurrent back propagation, Real time recurrent learning algorithm.
Counter Propagation Networks: Introduction to counter propagation networks, CMAC networks, ART networks, Application of neural networks, pattern recognition, optimization, associative memories, vector quantization, control.
Fuzzy Logic: Basic concepts of fuzzy logic, Fuzzy logic crisp set, Linguistic variable, Membership functions, Operation of fuzzy set, Fuzzy IF-THEN rules, Variable inference techniques, Defuzzification techniques, Basic fuzzy inference algorithm, Application of fuzzy logic, Fuzzy system design, Implementation of fuzzy system, Useful tools supporting design.
Support Vector Machines: Introduction, Support Vector classification, Support Vector regression, applications.
Basics of Genetic Algorithms: Evolution of Genetic and Evolutionary Algorithms, Applications.

Recommended Books:
1. Berkin R and Trubatch, "Fuzzy System Design Principles," Prentice Hall
2. Cristianini N and Taylor JS, "An Introduction to Support Vector Machines (and other Kernel – based learning methods)," Cambridge University Press

Reference Books:
3. Kosko B, "Nueral Networks and Fuzzy Logic," Prentice Hall
4. Haykin S, "Neural Networks," Pearson Education
5. Anderson JA, "An Introduction to Neural Networks," Prentice Hall
6. Jang JRS, Sun CT and Mizutani E, "Neuro-Fuzzy and Soft Computing – A Computational Approach to Learning and Machine Intelligence," Pearson Education
7. Sivanandam S and Deepa SN, "Principles of Soft Computing," Wiley India

Course Outcome:
On successful completion of this course the student will be able to:
- Understand the merits of soft computing techniques over the conventional computing techniques
- Comprehend the basics of the soft computing tools like ANNs, SVMs, fuzzy logic and evolutionary computing and their usage in real world applications

CIX-522 Industrial Automation and Robotics Laboratory [0 0 3 2]

At least 8 experiments are to be performed out of the following list:

1. To study various components of 3-DOF cleaning manipulator
2. To study encoders as a velocity, acceleration and displacement measurement
3. To find out the direct kinematics of given manipulator
4. To study the hydraulic actuators
5. To study the pneumatic actuators
6. To study the sonar sensor for environment mapping
7. To study the acceleration sensor
8. To plan a trajectory for specific task of manipulator
9. To study the differential drive of mobile robot
10. To programme a mobile robot on collision avoidance path
11. Programme the manipulator single axis for specified motion
12. Programme the manipulator for multiple axis for different specified tasks
13. To control the conveyor belt using PLC

The list of experiments given above is only suggestive. The Instructor may add new experiments as per the requirement of the course.

Course Outcome:
The experimental component of Laboratory exercise:

- Measures the motion and positioning of the 3-DOF manipulator
- Trajectory planning of mobile robot
- Pan Tilt position and velocity control LRF (Laser Range Finder) mapping
- Mapping by Vision sensor Kinematics of given manipulator

CIX-524 Medical Instrumentation Laboratory [0 0 3 2]

At least 8 experiments are to be performed out of the following list:

1. Record Electroencephalogram and demonstrate alpha waves
2. Concept of ECG system and placement of electrodes
3. Record a 12-lead Electrocardiogram
4. Identify arrhythmias from pre-recorded tapes
5. Measure motion artefact from electrodes and from skin
6. Construct an ECG amplifier from components
7. Measure blood pressure using a cuff or Use of sphygmomanometer for measurement of blood pressure
8. pH measurement of given biological sample
9. Measure volume changes by impedance plethysmography
10. Measure lung volumes using a spirometer
11. Measurement of respiration rate using thermistor
12. Concept of EEG system and placement of electrode
13. Delineate various components of ECG waveform
14. Filtering for removal of artefacts
15. Detection of Dicrotic notch in blood pressure waveform
16. Identification of heart sounds

The list of experiments given above is only suggestive. The Instructor may add new experiments as per the requirement of the course.

Course Outcome:
On successful completion of this course the student will be able to:

- Learn about the electrode placement for recording the bio-signals and their calibration
- Record EMG, EEG, ECG, Blood pressure, heart sounds, respiration rate and volumes
- Analysis and inference of above mentioned bio-signals

Detailed Course Content of Electives

CIX-580 Smart Sensors and Sensor Networking [3 0 0 3]

Review of Basic Concepts: Measurement system, transducers, sensors and actuators; signal conditioners; data communications and networking.
Basics of Smart Sensors: Definition and architecture of smart sensor; different levels of integration in small sensors, differences between smart, intelligent and network sensors ;advantages of smart sensors ;smart actuators and transmitters.
Smart Sensor Technologies: IC Technologies: thick film, thin film and monolithic IC technologies; Micro-machining processes: materials for micro-machining, wafer bonding, bulk and surface micromachining, other micro-machining techniques.
Examples of Smart Sensors: Principles, characteristics and constructional details of typical smart sensors for temperature, humidity, pressure and vibrations.
Basics of Sensor and Actuator Networking: Field-level, controller-level and enterprise-level networks; Sensor and actuator network (SAN): Network topologies; seven-layer OSI model of communication system.
Wired Network Protocols: RS-422, RS-485, HART and Foundation Fieldbus protocols, comparison with Ethernet (IEEE – 802.3) protocol.
Wireless Network Protocols: Need and advantages of wireless sensor and actuator network(WSAN); Zigbee (IEEE – 802.15.4) protocol, Merits of Zigbee over WiFi (IEEE – 802.11) and Bluetooth for sensor and actuator networking.
IEEE Standard 1451: Introduction to IEEE Standard 1451: "Smart Transducer Interface for Sensors and Actuators"; highlights of parts 1451.1, 1451.2, 1451.3, 1451.4 and 1451.5 of the Standard.

Recommended Books:
1 Patranabis D, "Sensors and Transducers," Prentice Hall
2 Frank R, "Understanding Smart Sensors", Artech House

Reference Books:
3 Callaway EH, "Wireless Sensor Networks : Architecture and Protocols," Auerbach Publications
4 Anand MMS, "Electronic Instruments and Instrumentation Techniques," Prentice Hall
5 William Stallings, "Data and Computer Communications," Pearson Education
6 IEEE Standard 1451, "Smart Transducer Interface for Sensor and Actuators"

Course Outcome:
On successful completion of this course the student will be able to:
- Understand the concept of smart sensor, intelligent sensor, network sensors, hardware schematics, level of integration , transduction principle, functional capabilities of smart and intelligent transducer
- Gain knowledge on IEEE 1451 smart transducer interface for sensor and actuator
- Understand the functionality and usage of different types of smart/intelligent sensors used extensively in industrial and home, vehicle automation
- Gain knowledge on concept of networking of sensor, functions of different layers, wired sensor network protocols, components and tools to implement the sensor network

CIX-581 Advanced Measurement Systems [3 0 0 3]

Intrinsically Safe Measurement Systems: Pneumatic measurement systems: flapper-nozzle, relay, torque balance transmitters, transmission and data presentation, Intrinsically safe electronic systems: the Zener barrier, energy storage calculations.
Heat transfer effects in measurement systems: Introduction, Dynamic characteristics of thermal sensors, Constant-temperature anemometer system for fluid velocity measurements. Katharometer systems for gas thermal conductivity and composition measurement.
Optical measurement systems: Introduction: types of system, Sources: principles, hot body, LED and LASER sources, Transmission medium: principles, optical fibers, Geometry of coupling of detector to source, Detectors and signal conditioning elements: thermal and photon detectors, measurements systems: intensity and wavelength modulation, interferometers.
Ultrasonic measurement systems: Basic ultrasonic transmission link, piezoelectric ultrasonic transmitters and receivers, Principles of ultrasonic transmission: wave properties, acoustic impedance, attenuation, stationary waves, response, Doppler effect, Examples of ultrasonic measurement systems: pulse reflection, medical imaging, Doppler, cross-correlation and transit time flowmeters.
Gas Chromatography: Principles and basic theory, Typical gas chromatograph, Signal processing and operations sequencing.
Data acquisition and communications systems: Time division multiplexing, Typical data acquisition system, Parallel digital signals, Serial digital signals, Error detection and correction, Frequency shift keying, Communication systems for measurement.

Recommended Books:
1. Bentley JP, “Principles of Measurement Systems,” Pearson Education
2. Doebelin EO, “Measurement Systems – Application and Design,” Tata McGraw-Hill

Reference Books:
3. Dally, “Instrumentation for Engineering Measurements,” Wiley India
4. Northrop, “Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation”, Taylor & Francis
5. Radhakrishnan, “Instrumentation Measurements and Experiments in Fluids”, Taylor & Francis

Course Outcome:
On successful completion of this course the student will be able to:
- Realize an advanced measurement system is discussed from the viewpoints of measurement principle, sensors and signal processing
- Specialized in measurement systems, which are important in industrial applications such as flow measurement system for fluid mechanics, effects of heat transfer, ultrasonic measurement system are covered
- Each topic has been developed in logical progression with the up-to-date information on this field of research
- Number of selected problems will be worked out to illustrate different concepts clearly

CIX-582 Robust and Optimal Control [3 0 0 3]

Introduction: Norms for signals and systems, Input-Output Relationships, Internal stability, Asymptotic Tracking, Performance.
Modeling of Uncertain Systems: Structured and unstructured uncertainty, linear fractional transformation.
Robust Design Specifications: Small gain theorem and Robust stabilization, performance consideration, structured singular values.
H_∞ Design: Mixed sensitivity H_∞ optimization, 2-degreee of freedom H_∞ design, H_∞ sub optimal solution, Formula for discrete time cases.
H_∞ Loop Shaping Design: Robust stabilization against normalized co-prime factor perturbation, loop shaping design procedures, Formula for discrete time case.
Design for Robust Performance: The modified problem, spectral factorization, solution of the modified problem, design.
Calculation of Variations: Fundamental concepts, minimization of functions, minimization of functionals, functional of a single function, functionals involving several independent functions, Piecewise smooth extremals, constrained extremal, Pontryagins minimum principles, control and state variable inequality constraint.
Optimal Feedback Control: Formulation of optimal control problem, selection of performance criteria for minimum time, minimum energy, Minimum fuel, Principle of optimality, Hamilton –Jacobi- Bellman equation, State regulator, output regulator and tracking problems.
Discrete Linear Regulator Problems: Numerical solution of the Riccati equation. Use of linear state regulator results to solve other linear optimal control problems. Sub optimal linear regulators-continuous and discrete time systems. Minimum time problems, minimum control effort problems.
Dynamic Programming: Multi-stage decision process in discrete time, principle of causality and optimality, Multi stage decision process in continuous time. Numerical solution of two-point boundary value problem, .minimization of functions, the steepest decent method.

Recommended Books:
1. Kemin Zhou, “Essentials of Robust Control”, Prentice Hall
2. Doyle JC, Francis BA and Tannenbaum AR, “Feedback Control Theory,” Macmillan Publishing Company

Reference Books:
3. Kirk DE, “Optimal control theory-An introduction,” Prentice Hall
4. Nagrath J and Gopal M, “Control system Engineering,” Wiley Eastern
5. Naidu DS, “Optimal Control Systems,” CRC Press

Course Outcome:
On successful completion of this course the student will be able to:
- Gain knowledge in design of linear quadratic regulator controller for linear systems in tracking and regulator modes
- Gain knowledge in design of robust controller for linear time invariant system with parametric uncertainty in components and disturbance acting on the system

CIX-583 Power Electronics and Drives [3 0 0 3]

Review of Power Semiconductor Devices: Power diodes – Power transistors – Characteristics of SCR, TRIAC, Power MOSFET, IGBT, GTO, MCT, LASCR – Thyristor protection circuits – Thyristor triggering circuits – Commutation – Natural, forced commutation.
Converters: Single phase – Three phase – Half controlled – Full controlled rectifiers – Dual converters – Effect of source and load inductance – Cyclo converters - AC regulators.
Inverters and Choppers: Voltage Source inverters –bridge inverters, Current source inverters – voltage and waveform control of inverters. DC choppers – step up and step down – uninterrupted power supplies.
DC Drives: Basic characteristics of DC motor – Operating modes – quadrant operation of chopper – Closed loop control of DC drives.
AC Drives: Induction motor – Performance characteristics – Stator and rotor voltage control, frequency and voltage control – Current Control – Introduction to synchronous motor, stepper motor, switched reluctance motor drives – Basics of vector control.

Recommended Books:
1. Rashid MH, “Power Electronics,” Pearson Education
2. Dubey GK, “Power semiconductors and Drives,” Prentice Hall

Reference Books
3. Bose BK , “Modern Power Electronics and AC Drives,” Pearson Education
4. Vithyathil J, “Power Electronics: Principles and Applications,” Tata McGraw-Hill
5. Mohan N, Undeland TM and Robbins WP, “Power Electronics,” Wiley India
6. Subramaniam V, “Thyristor control of Electrical Drives,” Tata McGraw-Hill

Course Outcome:
On successful completion of this course the student will be able to:
- Understand the operation of controlled rectifiers, choppers, inverters and their applications
- study about voltage source inverter, current source inverter and PWM
- Learn about the applications of power semiconductor devices for the speed control of AC and DC motors

CIX-584 Sensor Data Fusion [3 0 0 3]

Introduction: Sensors and sensor data, Limitations of single sensor, Advantages of multisensor data fusion, Multisensor data fusion applications, Data fusion models, Generic fusion architectures
Algorithms for Data Fusion: Taxonomy of algorithms for multi-sensor data fusion. Learning of fusion models: Learning Bayesian classifier, Rule learning from decision three algorithms.
Estimation: Kalman filtering, practical aspects of Kalman filtering, extended Kalmal filters, partical filter, Decision level identify fusion. Knowledge based approaches.
Advanced Filtering: Data information filter, extended information filter. Decentralized and scalable decentralized estimation. Sensor fusion and approximate agreement. Optimal sensor fusion using range trees recursively. Distributed dynamic sensor fusion.
High Performance Data Structures: Tessellated, trees, graphs and function. Representing ranges and uncertainty in data structures. Designing optimal sensor systems within dependability bounds. Implementing data fusion system, Application of multisensor data fusion for mobile robot mapping and Navigation.

Recommended Books:
1. Das SK, “High-level Data Fusion,” Artech House
2. Hall DL, “Mathematical techniques in Multisensor data fusion,” Artech House

Reference Books
3. Brooks RR and Iyengar SS, “Multi-Sensor Fusion,” Prentice Hall
4. Gelb A, “Applied Optimal Estimation,” MIT Press
5. Candy JV, “Signal Processing,” McGraw-Hill
6. Liggins.II, “Handbook of Multisensor Data Fusion”, Taylor & Francis

Course Outcome:
On successful completion of this course the student will be able to:
- Understand recent trends in sensor technology and its engineering applications
- Gain knowledge on multi-sensor data fusion techniques for intelligent systems focused on mobile robot mapping.
- Gain knowledge on different concepts of smart sensors and systems, and their design methods

CIX-585 Data Acquisition and Telemetry [3 0 0 3]

Data Acquisition System: Definition and generalized block diagram of data acquisition system (DAQ), Classification of DAQ, working principle block diagram, construction and salient features of the following data acquisition systems: Analog data acquisition system using time division multiplexing, Analog data acquisition system using frequency division multiplexing, Digital data acquisition system with different configurations and Data logger.
Introduction to Telemetry: Meanings and importance of telemetry, signal formation, conversion and transmission, general block diagram of telemetry system, classification of telemetry system, signal transmission media: Wires and cables, Power line carrier communication, terrestrial and satellite radio links, optical fiber communication, Multiplexing – TDM, FDM and WDM.
Analog Communication Techniques: Analog communication techniques: analog modulation of AC carrier; amplitude modulation of AM wave and frequency spectrum, frequency modulation and frequency spectrum of FM wave, Phase modulation and frequency spectrum of PM wave. Analog modulation of pulse carrier; basis of PAM, PFM.
Digital Communication Techniques: Digital modulation of pulse carrier, basis of PCM, DCPM; Digital modulation of AC carrier, ASK, FSK, PSK, error detection and correction methods, error control techniques.
Telemetry Systems: Direct voltage and current telemetry system, AM and FM telemetry system, Multi-channel PAM and PWM telemetry system, single and multi-channel digital telemetry system, modem based telemetry system, short range radio telemetry and satellite telemetry system, fibre optics telemetry system.

Recommended Books:
1. Karp HR (Ed.), “Basics of Data Communication,” McGraw-Hill
2. Tomasi W, “Fundamentals of Electronic Communication Systems,” Prentice Hall

Reference Books:
3. Gruenberg EL, “Handbook of Telemetry and Remote Control,” McGraw-Hill
4. Ginzberg, Lekhtman and Malov, “Fundamentals of Automation and Remote Control,” Mir Publishers
5. Rangan CS, Sharma GR and Mani VSV, “Instrumentation Devices and Systems,” Tata McGraw-Hill

Course Outcome:
On successful completion of this course the student will be able to:
- Understand the functionality of different components and configuration of data acquisition system
- Understand the working and functionality of the Data Logger
- Gain knowledge on different telemetry systems working principle, design techniques, signal transmission method, media and salient features
- Gain knowledge on digital communication techniques and applications of single and multiple channel digital telemetry systems

CIX-586 Biomedical Signal Analysis [3 0 0 3]

Introduction to Biomedical Signals: Nature of Biomedical Signals, Objectives of Biomedical Signal Analysis, Difficulties in Biomedical Signal Analysis, Computer-aided Diagnosis, ECG, PCG.
Filtering for Removal of Artifacts: Random noise, structured noise, and physiological interference, stationery versus nonstationary processes, Noise in the event-related potentials, High-frequency noise in the ECG, Motion artifact in the ECG, Power-line interference in the ECG signals, Maternal interference in fetal ECG, Muscle-contraction interference in VAG signals, potential solution to the problem. Time-domain Filters, Frequency-domain Filters, The Wiener Filter, Adaptive Filters for Removal of Interference, Filter selection.
Event Detection: Detection of Events and Waves, Correlation Analysis of EEG channels, Cross-spectral Techniques, the Matched Filter, Detection of the P Wave, Homographic Filtering, Applications: ECG Rhythm Analysis, Identification of Heart Sounds, Detection of the Aortic Component of S2
Waveshape and Waveform Complexity: Illustration of the problem with Case-studies, Analysis of Event-related Potentials, Morphological Analysis of ECG Waves, Envelope Extraction and Analysis, Analysis of Activity, Applications: Normal and Ectopic ECG Beats, Analysis of Exercise ECG, Analysis of Respiration.
Frequency-domain Characterization: Illustration of the Problem with Case-studies, Estimation of the Power Spectral Density Function, Measures Derived from PSDs.
Modeling Biomedical Systems: Point Processes, Parametric System Modeling, Autoregressive Modeling, Pole-zero Modeling, Electromechanical Models of Signal Generation, Applications: Heart-rate Variability, Spectral Modeling and Analysis of PCG Signals.

Recommended Books:
1. Rangayyan RM, “Biomedical Signal Analysis,” Wiley India
2. Bronzino JD, (Ed.), “Biomedical Engineering Handbook,” CRC Press

Reference Books:
3. Reddy DC, “Modern Biomedical Signal Processing,” Tata McGraw-Hill
4. Akay M, “Biomedical Signal Processing,” Academic Press
5. Tompkins WJ (Ed.), “Biomedical Signal Processing,” Prentice Hall

Course Outcome:
On successful completion of this course the student will be able to:
- Demonstrate theoretical foundation on digital signal processing; understand the relationship between systems and signals, describe systems or filters using input–output equation, impulse response, frequency response, and transfer function
- Use FFT for signal analysis with the understanding of sampling effects and windowing effects
- implement filters for the processing of biomedical signals to improve signal quality

CIX-587 Identification and Adaptive Control [3 0 0 3]

Introduction: Problems of identification and control estimation problem and classification, Estimation problems for continuous and Discrete case, Linear and non linear estimation problems.
Adaptive Control Problem: Introduction, types of representation, Models and mode classifications, Transfer function and impulse response.
Method of Identification: Impulse response identification methods, Least square identification method, method of maximum likelihood, Recursive identification using Least square methods.
Kalman Filtering: Introduction to smoothing, filtering and prediction, Kalman Filter, Application of Kalman filtering algorithm to identification and adaptive controls.
Advances in Adaptive Control: Adaptive control using model reference techniques, self tunning control and self tracking control.
Applications: Application of state estimation in electromechanical systems, Maximum likelihood estimation for electromechanical systems. Some case studies.

Recommended Books:
1. Astrom KJ and Wittenmark B, "Adaptive Control," Pearson Education
2. Landan ID, "System Identification and Control Design," Prentice Hall

Reference Books:
3. Chalam VV, "Adaptive Control Systems – Techniques and Applications," CRC Press
4. Nagrath IJ and Gopal M, "Control Systems Engineering," Anshan Publishers
5. Goodwin GC and Sin KS, "Adaptive Filtering Prediction and Control," Dover Publications
6. Sanchez M, Juan M and Jose R, "Adaptive Predictive Control for concept to Plant optimization," Prentice Hall

Course Outcome:
On successful completion of this course the student will be able to:
- Understand non parametric methods of system identification
- Understand different types of parametric estimation methods
- Know the design procedure of adaptive control schemes for linear and non-linear systems

CIX-588 Physiological Control Systems [3 0 0 3]

Brief introduction to Human Anatomy and physiology: Basic human anatomy and physiology of the cardiovascular, nervous, muscular, and respiratory systems and their interactions;
Transport mechanisms: Emphasis on the physical and engineering principles governing the systems, various transport mechanisms of ions and molecules, concept of action potential.
Mathematical Modeling: Generalized system properties, Linear model of physiological systems, Laplace transform and concept of T.F., impulse response and convolution concept, computer analysis and simulation, differences between engineering and physiological control systems.
Static Analysis of Physiological Systems: Open loop vs closed loop systems, steady-state operating point, and regulation of cardiac output.
Time Domain Analysis of Linearized Physiological Systems: Open loop and closed loop – transient responses, Descriptions of impulse and step responses for a generalized second order systems, Transient response , Effect of external disturbances and parameter variation,
Frequency Domain Analysis: Steady state response to sinusoidal inputs, graphical representation of frequency response, frequency response of a model of circulatory system, frequency response of general human body.
Stability Analysis: Stability and transient response, various approaches of linear system stability analysis, Root locus plots, RH – stability criterion, Nyquist criterion for stability.

Recommended Books:
1. Khoo MCK, “Physiological Control Systems – Analysis, Simulation and Estimation,” Wiley-Blackwell
2. VanDeGraff KM and Rhees RW, “Schaum's Easy Outline of Human Anatomy and Physiology,” Tata McGraw-Hill
Reference Books:
3. Ogata K, “Modern Control Engineering,” Prentice Hall
4. Nagrath IJ and Gopal M, “Control Systems Engineering,” Anshan Publishers
5. Friendland B, “Advanced Control System Design,” Prentice Hall

Course Outcome:
On successful completion of this course the student will be able to:
- Understand the anatomy of human body (cardiovascular, respiratory and nervous system) and its equivalent electrical modelling.
- Learn to make electrical model of above systems and their realization.

CIX-589 Industrial Instrumentation [3 0 0 3]

General Measurement System: Measurement system-purpose, structure and elements, static characteristics of measurement system, accuracy of measurement systems in the steady state.
Characteristics of Measurement System: Transfer function, identification of dynamics, dynamic errors, techniques for dynamic compensation, loading effects and two port networks.
Signals and noise in measurement systems: Introduction, statistical representation of random signals, effects of noise and interference, noise sources and coupling mechanisms, methods of reducing effects of noise and interference, reliability of measurement systems.
Sensing Elements: Resistive, capacitive, inductive, electromagnetic, thermoelectric, elastic, piezoelectric and peizoresistive and electrochemical sensing elements.
Signal Conditioning Elements: Deflection bridges, amplifiers, A.C. carrier systems, Current transmitters, oscillators and resonators.
Signal Processing and Data Presentation: ADC, microcomputer system, signal processing calculations, steady state compensation, dynamic digital compensation and filtering, data presentation elements.

Recommended Books:
1. Bentley JP, "Principles of Measurement Systems," Pearson Education
2. Doebelin EO, "Measurement Systems – Application and Design," Tata McGraw-Hill

Reference Books:
3. Dally, "Instrumentation for Engineering Measurements," Wiley India
4. Northrop, "Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation", Taylor & Francis
5. Radhakrishnan, "Instrumentation Measurements and Experiments in Fluids", Taylor & Francis

Course Outcome:
On successful completion of this course the student will be able to:
- Understand the concept of measurement system, its analysis and study of various errors.
- Understand the concept of installation and calibration of various sensors and noise and error reduction techniques
- Deals with the design issues of measurement system and analysis

CIX-590 Human Computer Interfacing [3 0 0 3]

An Introduction to Human Computer Interfacing: Introduction to Human-computer Interaction, The nature of human-computer interaction. Methodology for Designing User-computer Interfaces:- conceptual, semantic, syntactic, and lexical levels of the design of an interactive system.
Interaction Tasks, Techniques, and Devices: Design of novel interaction techniques, Modes of human-computer communication, Voice, Gesture and Eye movement. P300 based communication, Thought Translation device (TTD), Graz-HCI research, μ-rhythm synchronization and de-synchronization.
BCI Techniques: General Signal processing and machine learning tool for HCI analysis, Spectral filtering, spatial filtering, PCA, ICA, AR modeling, CWT, DWT Classification Techniques: Bayesian Analysis, LDA (Linear Discriminant Analysis) SVM (Support Vector Machine) ANN (Artificial Neural Network)
User Interface Software: Languages and tools for specifying and interfaces, Dialogue independence, UIMS (user interface management system) approach .BCI2000: A general purpose software platform for HCI research.
Applications of HCI: HCI for Communication and motor control, combining HCI and Virtual reality: Scouting Virtual worlds.

Recommended Books:

1. Dornhege G, Millan JDR, Hinterberger T, Mcfarland DJ and Muller KR, "Toward Brain-Computer interfacing," MIT Press
2. Rangayyan RM, "Biomedical Signal Analysis: a case study Approach," Wiley India

Reference Books:

3. Tompkins WJ (Ed.), "Biomedical signal Processing," Prentice Hall
4. Berger TW, Chapin JK et.al., "Brain-Computer Interfaces-An International Assessment of Research and Development trends," Springer Science
5. Bronzino JD (Ed.), "The Biomedical Engineering Handbook," CRC Press

Course Outcome:

On successful completion of this course the student will

- Review various physiological signals
- Learn Interfacing of various physiological signals with external world
- Familiarize with associated research directions

CIX-591 Computer Networks [3 0 0 3]

Introduction: Uses of Computer Networks, Network Hardware and Software, OSI, TCP/IP Reference Models, Networking Terminology, Internet Evolution**.**
Ethernet Technology: IEEE Standard, Switched Ethernet, fast Ethernet, Gigabit Ethernet, Logical link control Retrospectives on Ethernet.
ATM Networks: Introduction, Reference Model, Routing and Addressing, ATM Signalling, ATM Switching Overview, ATM Traffic Management & Congestion, SS7.
Wireless Networks: Introduction, Wireless LANs, IEEE 802.11 Standard, Physical Layer, MAC sub Layer, 802.11 Frame Structure and Services, ad-hoc networks: Introduction, Proactive and Reactive protocols-AODV, DSR and TORA, performance issues- Quality of Service (QoS).
Bluetooth Technology, Bluetooth Architecture and Applications, Protocol Stack, Radio layer, Baseband Layer, L2CAP Layer, Frame Structure.
Broad Band Wireless Networks: IEEE 802.16 Standard, Comparison of 802.11 with 802.16, 802.16 Protocol Stack, 802.16 Physical Layer, 802.16 MAC sub Layer Protocol, 802.16 Frame Structure and Services.
Sensor Networks: Introduction, topology and Applications

Recommended Books:
1. Tananbum AS, “Computer Networks,” Pearson Education
2. Forouzan BA, “Data Communication and Networking,” Tata McGraw Hill

Reference Books:
3. Peterson LN and Davie BS, “Computer Networks: A system approach,” Elsevier
4. Walrand J and Varaiya P, “High Performance Communication Networks,” Morgan Kauffman
5. Vasseure JP, Picavet M and Demeester P, “Network Recovery Protection and Restoration of Optical, SONET-SDH, IP and MPLS,” Elsevier
6. Stalling William, “Wireless communication and networks,” Pearson Education

Course Outcome:
This course is aimed at providing basic knowledge of various computer networks both wired and wireless types and their related issues.

CIX-592 System Modeling and Reliability [3 0 0 3]

System Models and Studies: Concept of a system, system Environment, stochastic Activities, continuous and discrete systems, systems modeling, types of models, Principles used in Modeling, system Analysis & design.
System Representation: Introduction, Block diagram presentation, Standard Block – Diagram, Signal flow graphs, Determination of overall system response using Block diagram and Signal flow for the various inputs.
System Equations: Introduction, Electric circuits and components, Basic linear algebra, state concept, Mechanical Translation system, analogous circuits, Mechanical rotational system.
Probability concepts in simulation: Stochastic variables, discrete probability functions, continuous probability functions, Measures of probability. Functions, numerical evaluation of continuous probability functions, Estimation of mean variances, and Correlation, Random number generator and Properties of Random Numbers.
System Simulation: Step in simulation study, techniques of simulation, comparison of simulation and analytical methods, Experimental Nature of simulation, types of system simulation, Numerical computation Technique for continuous models, Numerical computation technique for Discrete models, Distributed lag models, Real Time Simulation, Selection of Simulation Software, Simulation Packages, Trends in simulation software.
Introduction to system Reliability: Reliability, MTTF, MTBF, failure data analysis, hazard rate, System reliability using: - series configuration, parallel configuration, mixed configuration, Markov model, fault tree analysis. Reliability improvement and maintainability.
Illustrations of problems and case studies using soft computing algorithm.

Recommended Books:
1. Nagrath IJ and Gopal M, “System Modeling and Analysis,” Tata McGraw-Hill
2. Srinath LS, “Reliability Engineering,” East West Press

Reference Books:
3. Gorden G, “System Simulation,” Prentice Hall
4. Law AM and Kelton WD, “Simulation Modeling and Analysis,” Tata McGraw-Hill
5. Banks J, Carson JS, Nelson BL and Nicol DM, “Discrete Event System Simulation,” Prentice Hall

Course Outcome:
On successful completion of this course the student will be able to:
- Know the needs and applications of computer simulation
- Learn the concepts of mathematical modelling and computer simulation techniques
- Learn the importance of reliability, maintainability and safety aspects

CIX-593 PLC, DCS and SCADA [3 0 0 3]

Computer Based Control: Implementing control system using computer or microprocessor; computer based controller: hardware configuration and software requirements.
Distributed Control System: Meaning and necessity of distributed control; hardware components of DCS; DCS software.
Introduction Programmable Logic Controller (PLC): What is PLC?, PLC versus microprocessor/microcontroller/computer, advantages and disadvantages of PLC, architecture and physical forms of PLC.
Basic PLC functions: Registers: holding, input and output registers; Timers and timer functions; counters and counter functions
Intermediate PLC functions: Arithmetic functions: addition, subtraction, multiplication, division and other arithmetic functions; Number comparison and conversion.
Data Handling Functions of PLC: Skip function and applications; master control relay function and applications; jump with non-return and return; data table, register and other move functions.
Bit Functions of PLC: Digital bit functions and applications; sequencer functions and applications.
Advanced Functions of PLC: Analog input and output functions, analog input and output modules, analog signal processing in PLC; PID control function, network communication function.
PLC programming: PLC programming languages, ladder programming, mnemonic programming and high level language programming.
SCADA: Supervisory control versus distributed control; Layout and parts of SCADA system, detailed block schematic of SCADA system; Functions of SCADA system: data acquisition, monitoring, control, data collection and storage, data processing and calculation, report generation; MTU: functions, single and dual computer configurations of MTU; RTU: functions, architecture / layout; MTU-RTU communication and RTU-field device communication.

Recommended Books:
1. Johnson CD, “Process Control Instrumentation Technology,” Prentice Hall
2. Chemsmond CJ, “Basic Control System Technology,” Viva Books

Reference Books:
3. Webb JW and Reis RA, “Programmable Logic Controllers,” Prentice Hall
4. Hackworth JR and Hackworth FD, “Programmable Logic Controllers,” Pearson Edition
5. Boyer SA, “Supervisory Control and Data Acquisition (SCADA),” International Society of Automation

Course Outcome:
On successful completion of this course the student will be able to:
- Understand the architecture, hardware, software and interfacing of PLC and SCADA with the external world
- Learn PLC and SCADA programming techniques for different processes
- Understand the architecture, hardware, software and interfacing of DCS with the external world using various industrial data communication protocols

CIX-594 Analytical Instrumentation [3 0 0 3]

Introduction: Difference between analytical and other instruments, sampling, sampling system for liquids and gases, sampling components, automatic and faithful sampling.
Gas Analysis: Gas Chromatography – principles & components, Thermal conductivity gas analyzers, Heat of reaction method, Estimation of Oxygen, Hydrogen, Methane, CO_2, Carbon monoxide etc. in binary or complex gas mixtures, paramagnetic oxygen analyzer, Electro chemical reaction method, Polarography, Density measurement.
Humidity and Moisture Measurements: Humidity measurement: definitions – absolute, specific, relative humidity and dew point, Dry and wet bulb psychrometer, Hair hygrometer, dew point meter. Moisture Measurement: definitions, electrical methods, NMR method, IR method.
Chemical Composition Measurements: Newtonian and Non Newtonian flow, Measurement of viscosity and consistency, Laboratory and on line methods, Measurement of pH:- definition and methods, redox potential, electrical conductivity, conductivity cell and applications, density measurement: solids, liquids, gages.
Spectrochemical Analysis: Classification of techniques, Principles and components, emission spectrometery:- flame emission, atomic absorption type, Dispersive techniques, scheme for UV, IR and near IR analysis, comparison of methods, X-ray analyzers NMR spectrometry, ESR spectroscopy, Mass spectrometery.
Analytical Electron Microscope: An overview

Recommended Books:
1. Patranbis D, “Principles of Industrial Instrumentation” , Tata McGraw-Hill
2. Jones EB, “Instrument Technology, Vol II”, Butterworths Scientific

Reference Books:
3. Khare RP, “Analytical Instrumentation an Introduction,” CBS Publication
4. Khandpur RS, “Handbook of Analytical Instruments,”, Tata McGraw-Hill
5. McMillan GK and Considine D, “Process/Industrial Instruments and Controls Handbook”, Tata McGraw-Hill

Course Outcome:
On successful completion of this course the student will understand:
- Liquid and gas sampling systems
- Principle and working of gas analysis instruments
- Principle and working of humidity and moisture measuring instruments
- Principle and working of chemical composition measuring instruments
- Principle and working of spectro-chemical analytical instruments

CIX-595 Medical Imaging and Processing [3 0 0 3]

Introduction: Medical imaging technology, systems, and modalities. Brief history; importance; applications; trends; challenges.
Medical Image Formation Principles: X-Ray physics; X-Ray generation, attenuation, scattering; dose. Basic principles of CT; reconstruction methods; artifacts; CT hardware. Mathematics of MR; spin physics; NMR spectroscopy; imaging principles and hardware; image artifacts. Nuclear Imaging: Imaging methods; mathematical principles; resolution; noise effect; 3D imaging; positron emission tomography; single photon emission tomography; ultrasound imaging; applications.
Medical Image Enhancement: Compensation for nonlinear characteristics of display or print media, intensity scaling, histogram equalization, edge enhancement, denoising, spatial domain and frequency domain methods, adaptive image filtering.
Image Segmentation: Histogram-based methods; region growing and watersheds; Markov random field models; active contours; model-based segmentation. Multi-scale segmentation; semi-automated methods; clustering-based methods; classification-based methods; multi-model segmentation.
Medical Image Analysis: Shape quantification; texture quantification, importance of texture in medical images, geometrical tools for analysis, Gabor filters, gradient based analysis.
Image Registration: Intensity-based methods; feature-based methods; transformation models; spatial domain and frequency domain methods; single modality and multimodality methods; automatic and interactive methods; similarity measures.
Visualization: Fundamentals of visualization; surface and volume rendering/visualization; animation; interaction.
Medical Image Archive, Retrieval and Communication: Picture archiving and communication system (PACS), Radiology Information Systems (RIS) and Hospital Information Systems (HIS); systems and formats: DICOM, teleradiology and telemedicine.

Recommended Books:
1. Webb S, “The Physics of Medical Imaging,” Taylor & Francis
2. Bankman IN, “Handbook of Medical Image Processing and Analysis,” Academic Press

Reference Books:
3. Dougherty G, “Digital Image Processing for Medical Applications,” Cambridge University Press
4. Sinha GR, Patel BC, “Medical Image Processing: Concepts and Applications,” Prentice Hall
5. Gonzalez RC, “Digital Image Processing,” Pearson Education
6. Jain AK, “Fundamentals of Digital Image Processing,” Prentice Hall

Course Outcome:
Students will be able to understand:
- the biological system of human body
- the various types of electrical signals that flow within it and associated electronic circuitry
- It helps to analyze the proper functioning of human body by analyzing the wave shape and the probable cause of disease.

CIX-596 Power System Operation and Control [3 0 0 3]

Introduction: Operating States, Preventive and Emergency control, Indian Electricity Grid Code, Co-ordination between different agencies in India.
Load Frequency Control: Introduction, Types of speed governing system and modeling, Mechanical, Electro-hydraulic, Digital electro-hydraulic governing system, Turbine modeling, Generator-load modeling, Steady-state and dynamic response of ALFC loop, the secondary ALFC loop, Integral control.
Multi-control-Area System: Introduction, Pool operation, Two-area system, Modelling the tie line, Static and dynamic response of two area system, Tie-line bias control, State space representation of two-area system, Generation allocation, Modern implementation of AGC scheme, Effect of GRC and speed governor dead-based on AGC.
Excitation System: Introduction, Elements of an excitation system, Types of excitation system, Digital excitation system, modeling.
Optimum Operating Strategies: Introduction, Generation mix, Characteristic of steam and Hydro-electric units, Optimum economic dispatch - neglecting Loss and with transmission loss, Computational steps, Derivation of loss formula, Calculation from Jacobian matrix equation, Economic dispatch for Hydro-thermal plants, Short-term Hydro-thermal scheduling, Hydrothermal co-ordination, Reactive power scheduling.
Unit Commitment: Introduction, Constraints in unit commitment, Thermal unit constraints, Hydro-constraints, Unit commitment solution method - Priority list method, Dynamic programming solution.
Power System Restructuring: Introduction, Regulation vs. Deregulation, Competitive Market for Generation, The Advantages of Competitive Generation, Electric Supply Industry Structure under Deregulation in India, Restructuring Models.

Recommended Books:
1. Elgerd OI, “Electric Energy Systems Theory an Introduction,” McGraw-Hill Book Company
2. Wood, AJ and Wollenberg BF, “Power Generation Operation and Control,” Wiley India
3. Kothari, DP and Dhillon, JS, “Power System Optimization,” PHI Learning Pvt Ltd
4. Kundur P, “Power System Stability and Control,” Tata McGraw-Hill Book Company

Course Outcome:
Students will be able to understand:
- load frequency control and multicontrol area system
- the optimum operating strategies including hydrothermal scheduling techniques, maintenance scheduling and unit commitment
- the concept of power system restructuring

CIX-597 Power System Planning and Reliability [3 0 0 3]

Introduction : Hierarchy of modern power system planning, Brief description about short term and long term planning, Introduction to Reliability Engineering: Definition of reliability, Probabilistic reliability, Repairable and non-repairable items, the pattern of failures with time (non-repairable and repairable items).
Generation expansion planning: fundamentals, Economic analysis, planning including maintenance scheduling.
Network expansion planning: Introduction, Heuristic methods, Mathematical optimization methods.
Reliability Mathematics : The general reliability function, The exponential distribution, Mean time to failure and repair, series and parallel systems, Markov processes, System reliability using network and state space method.
Static Generating Capacity Reliability Evaluation: Introduction, Capacity outage probability tables, Loss of load probability (LOLP) method, Loss of energy probability (LOLE) method, Frequency and duration approach.
Spinning Generating Capacity Reliability Evaluation: Introduction, Spinning capacity evaluation, Derated capacity levels.
Transmission System Reliability Evaluation: Average interruption rate method, the frequency and duration approach, Stormy and normal weather effects, The Markov processes approach, System studies.

Recommended Books:
1. Billinton R, “Power System Reliability Evaluations,” Gordon and Breach Science Publishers, New York
2. Wang X and McDonald JR, “Modern Power System Planning,” McGraw-Hill Book Company
3. Endrenyi J, “Reliability Modeling in Electric Power Systems,” John Wiley & Sons, New York
4. Patrick D.T. O'Connor, “Practical Reliability Engineering,” John Wiley & Sons, (Asia) Pvt. Ltd., Singapore
5. Ryabinin I, “Reliability of Engineering Systems - Principles and Analysis,” MIR Publishers, Moscow

Course Outcome:
Students will be able to understand:
- the fundamentals of modern power system planning and reliability
- the static and spinning generating capacity reliability evaluation
- the basic concepts of Expansion planning and transmission system reliability evaluation

CIX-598 Power System Reliability [3 0 0 3]

Introduction to Reliability Engineering: Definition of reliability, Probabilistic reliability, Repairable and non-repairable items, the pattern of failures with time (non-repairable and repairable items).
Reliability Mathematics: The general reliability function, The exponential distribution, Mean time to failure and repair, series and parallel systems, Markov processes, System reliability using network and state space method.
Static Generating Capacity Reliability Evaluation: Introduction, Capacity outage probability tables, Loss of load probability (LOLP) method, Loss of energy probability (LOLE) method, Frequency and duration approach.
Spinning Generating Capacity Reliability Evaluation: Introduction, Spinning capacity evaluation, Derated capacity levels.
Transmission System Reliability Evaluation: Average interruption rate method, the frequency and duration approach, Stormy and normal weather effects, The Markov processes approach, System studies.
Composite System Reliability Evaluation Considering Interconnection: Service quality criterion, Conditional probability approach, Two-plant single load and two load systems. The probability array for two interconnected systems, Loss of load approach, Interconnection benefits.
Direct Current Transmission System Reliability Evaluation: System models of failure, Loss of load approach, Frequency and duration approach, Spare-valve assessment, multiple bridge equivalents.

Recommended Books:

1. Billinton R, “Power System Reliability Evaluations,” Gordon and Breach Science Publishers, New York
2. Endrenyi J, “Reliability Modeling in Electric Power Systems,” John Wiley & Sons, New York
3. Wang X and McDonald JR, “Modern Power System Planning,” McGraw-Hill Book Company
4. Patrick D.T. O'Connor, “Practical Reliability Engineering,” John Wiley & Sons, (Asia) Pvt. Ltd., Singapore
5. Ryabinin I, “Reliability of Engineering Systems- Principles and Analysis,” MIR Publishers, Moscow

Course Outcome:

Students will be able to understand:

- the main principles and different methods in power system reliability analysis
- composite system reliability considering inter-connection and its evaluation
- direct current transmission system reliability and its evaluation