UNIVERSITY OF MUMBAI

Bachelor of Engineering

Instrumentation Engineering (Fourth Year – Sem. VII & VIII), Revised course
(REV- 2012) from Academic Year 2015 -16,
Under

FACULTY OF TECHNOLOGY

(As per Semester Based Credit and Grading System)

From Dean's Desk:

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEO's) and give freedom to affiliated Institutes to add few (PEO's) and course objectives and course outcomes to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. It was also resolved that, maximum senior faculty from colleges and experts from industry to be involved while revising the curriculum. I am happy to state that, each Board of studies has adhered to the resolutions passed by Faculty of Technology, and developed curriculum accordingly. In addition to outcome based education, semester based credit and grading system is also introduced to ensure quality of engineering education.

Semester based Credit and Grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes and Faculty of Technology has devised a transparent credit assignment policy and adopted ten points scale to grade learner's performance. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 12-13 weeks and remaining 3-2 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

Credit and grading based system was implemented for First Year of Engineering from the academic year 2012-2013. Subsequently this system will be carried forward for Second Year Engineering in the academic year 2013-2014, for Third Year and Final Year Engineering in the academic years 2014-2015 and 2015-2016 respectively.

Dr. S. K. Ukarande
Dean,
Faculty of Technology,
Member - Management Council, Senate, Academic Council
University of Mumbai, Mumbai

Preamble:

The overall technical education in our country is changing rapidly in manifolds. Now it is very much challenging to maintain the quality of education with its rate of expansion. To meet present requirement a systematic approach is necessary to build the strong technical base with the quality. Accreditation will provide the quality assurance in higher education and also to achieve recognition of the institution or program meeting certain specified standards. The main focus of an accreditation process is to measure the program outcomes, essentially a range of skills and knowledge that a student will have at the time of graduation from the program that is being accredited. Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

I, as Chairman, Board of Studies in Electrical Engineering of University of Mumbai, happy to state here that, Program Educational Objectives (PEOs) were finalized for undergraduate program in Electrical Engineering, more than twenty senior faculty members from the different institutes affiliated to University of Mumbai were actively participated in this process. Few PEOs were finalized for undergraduate program in Electrical Engineering are listed below;

- To provide the overall strong technical foundation to formulate, solve and analyse engineering problems during undergraduate program.
- To prepare students to demonstrate an ability to identify, formulate and solve electrical based issues.
- To prepare students to demonstrate ability in the area of design, control, analyse and interpret the electrical and electronics systems.
- To prepare students for successful career in industry, research and development.
- To develop the ability among students for supervisory control and data acquisition for power system application.
- To provide opportunity for students to handle the multidisciplinary projects.
- To create the awareness of the life-long learning and to introduce them to professional ethics and codes of professional practice.

The affiliated institutes may include their own PEOs in addition to the above list to support the philosophy of outcome based education, in addition to stated PEOs, objectives and expected outcomes are also included in the curriculum. I know, this is a small step taken to enhance and provide the quality education to the stake holders.

Chairman,
Board of Studies in Electrical Engineering,
University of Mumbai

Semester VII

Subject Code	Subject Name	Teaching Scheme		Credits Assigned		
		Theory	Pract/ Tut.	Theory	Pract/ Tut.	Total
ISC701	Industrial Process Control	4	2	4	1	5
ISC702	Biomedical Instrumentation	4	2	4	1	5
ISC703	Advanced Control Systems	4	2	4	1	5
ISC704	Process Automation	4	2	4	1	5
ISE705X	Elective-I	4	2	4	1	5
ISP706	Project-I	-	6	-	3	3
Total		20	16	20	8	28

Subject Code	Subject Name	Examination scheme							
		Theory Marks					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg.					
ISC701	Industrial Process Control	20	20	20	80	03	25	25	150
ISC702	Biomedical Instrumentation	20	20	20	80	03	25	25	150
ISC703	Advanced Control Systems	20	20	20	80	03	25	25*	150
ISC704	Process Automation	20	20	20	80	03	25	25	150
ISE705X	Elective-I	20	20	20	80	03	25	25	150
ISP706	Project-I	--	--	--	--	--	25	25	50
Total				100	400	--	150	150	800

*** Includes both Practical and Oral examination**

Semester VIII

Subject Code	Subject Name	Teaching Scheme		Credits Assigned		
		Theory	Pract/ Tut	Theory	Pract./ Tut.	Total
ISC801	Digital Control System	4	2	4	1	5
ISC802	Instrumentation Project Documentation and Execution	4	2	4	1	5
ISC803	Instrument and System Design	4	2	4	1	5
ISE804X	Elective II	4	2	4	1	5
ISP805	Project-II.	-	12	-	6	6
	Total	16	20	16	10	26

Subject Code	Subject Name	Examination scheme							
		Theory Marks					Term work	Pract./ Oral	Total
		Internal Assessment			End Sem exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg.					
ISC801	Digital Control System	20	20	20	80	03	25	25*	150
ISC802	Instrumentation Project Documentation and Execution	20	20	20	80	03	25	25	150
ISC803	Instrument and System Design	20	20	20	80	03	25	25	150
ISE804X	Elective II	20	20	20	80	03	25	25	150
ISP805	Project-II.	--	--	--	--	--	50	50	100
Total				80	320	--	150	150	700

Subject Code	Elective - I	Subject Code	Elective II
ISE7051	Advanced Embedded System	ISE8041	Nuclear Instrumentation
ISE7052	Image Processing	ISE8042	Power Plant Instrumentation

ISE7053	Functional Safety	ISE8043	Optimal Control theory
ISE7054	Process Modeling & Optimization	ISE8044	Nano Technology
ISE7055	Wireless communication	ISE8045	Fiber Optic Instrumentation

Project Guidelines

Project –I and II: Students groups and load of faculty per week
Project Groups: Students can form groups with minimum 2 (Two) and not more than 4 (Four)
Faculty Load: In semester VII - 1 (one) period of 1 hour per week per project group
In semester VIII - 2 (Two) period of 1 hour each per week per project group
Each faculty is permitted to take (guide) maximum 4 (Four) project groups.

Note: The project load for students in VII semester is 6hrs and 12 hrs in VIII semester.

Sub code	Subject Name	Teaching Scheme (Hrs)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ISC701	Industrial Process Control	4	2	-	4	1	-	5

Sub code	Subject Name	Examination Scheme							
		Theory(out of 100)				Term Work	Pract. and oral	Oral	Total
		Internal Assessment (out of 20)			End sem Exam				
		Test 1	Test 2	Avg.					
ISC701	Industrial Process Control	20	20	20	80	25	-	25	150

Subject Code	**Subject Name**	**Credits**
ISC701	**Industrial Process Control**	**5**
Course Objectives	• To make the students understand all the processes involved in the industries, the various unit operations and be able to apply control schemes to these processes to get the output with desired specifications. • To make the students acquainted with safety and hazards in industry.	
Course Outcomes	The students will be able to • Get a complete overview of strategies for process control. • Know all the industrial processes and demonstrate their knowledge in designing the control loops for these processes.. • Understand the safety related terms such as classification of hazards in the industry and design Hazard free plant.	

Module	Topics	Hrs.
1	**Control System for Heat transfer unit operations:** **Heat exchangers:** classification as per fluid flow arrangement and construction, feedback, feed-forward, bypass control schemes, fouling in heat exchangers. **Boiler controls:** Basic designs of boilers- fire-tube and water-tube boilers. Typical boiler equipment. Terms related- Shrink and swell effect and excess oxygen, boiler efficiency. Boiler controls- Steam temperature control, Boiler pressure control, Combustion control-Type 1,2,3 and 4, Drum level control-Single, two and three element, Furnace draft control, safety interlocks and Burner Management System. **Evaporator control:** Evaporator terminologies, Types of Evaporator and multiple effect evaporator, control systems for Evaporator – feedback, cascade, feed forward and selective control. **Furnace control:** Start- up heaters, fired re-boilers, process and safety controls.	13
2	**Control System for Heat and mass transfer unit operations** **Distillation column:** Basic principle, Distillation equipment and its accessories. Batch and continuous distillation, Binary product distillation, multi-product distillation, side-draw product distillation column. Distillation column control strategies- Top and bottom product composition controls, Using chromatograph, Pressure controls, Vacuum distillation, Vapour recompression and pressure control, Feed controls- Column feed controls and Feed temperature control, economizer **Dryer control:** Process of drying, types of dryer- Tray, Vacuum dryer, fluidized bed, Double drum dryer, rotary, turbo and spray, and their control strategies. **Crystallizers:** Super-saturation methods, Process of crystallization, types of crystallizer, control of evaporating crystallizer, cooling crystallizers, vacuum crystallizers. **Reactor control:** Reactor characteristics, runaway reaction, various schemes of temperature control of reactors.	12
3	**Miscellaneous process equipments** **Compressor-** Classification, Phenomenon of Surge for centrifugal compressors, Methods of surge control for compressors. **Gas turbine-** Introduction, gas turbine layouts, closed cycle gas turbine, Engine controls.	05
4	**Continuous Process Industries:** **Refinery Industry:** Process flow diagram, separation, treatment-Hydro-desulphurization unit, conversion methods- Fluid Catalytic Cracking, blending, sensors and contrl schemes.	07

	Iron and steel Industry: Process flow diagram, Sensors and Control schemes.	
5	**Batch Process Industries:** **Food processing:** Milk pasteurization. **Pharmaceutical industries**- Penicillin-G production, sensors and control schemes	07
6	**Safety in Instrumentation control systems:** Area and material classification as per IEC and NEC standard, techniques used to reduce explosion hazards, intrinsic safety, and installation of intrinsically safe systems.	04

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 question need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Oral Examination:
Practical/Oral examination will be based on entire syllabus.

Term work:
Term work consists of minimum six assignments/experiments, two case studies related to process industries, may be analytical or through Industrial visit. Suggested experiments may contain Process and Control Simulation on Distillation Column, Heat Exchanger etc.

The distribution of marks for term work shall be as follows:

Laboratory work (Experiments)	: 10 Marks
Laboratory work (Assignments / journal)	: 10 Marks
Attendance (Theory and Practical)	: 05 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Assessment:
Internal Assessment consists of two tests out of which, one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Text Books :

1. W.L.McCabe and Julian Smith "Unit operation and chemical engineering" Tata McGrawHill- fifth edition.
2. Bela G. Liptak "Instrument engineers handbook- Process control" Chilton book company- 3rd edition.
3. Bela G. Liptak "Instrumentation in the processing industries" Chilton book company-1st edition.

Reference Books :

1. M. Chidambaram, "Complete Control of Processes", Narosa Publishing House.
2. Douglas M. Concidine " Process industrial instruments and controls handbook" Mc-GrawHill- 4th edition.
3. George T. Austin "Shreve's chemical process industries" Mc-GrawHill- fifth edition.
4. George Stephenopoulos, "Chemical process control", PHI-1999.
5. David Lindsey, "Power Plant control and instrumentation – control of boilers HRSG", Institution of Engineering and Technology.
6. G.F. Gilman "Boiler Control Systems Engineering", 2005, ISA Publication.
7. A.M.Y.Razak, Industrial gas turbines Performance and operability", CRC Press Woodhead Publishing Limited and CRC Press LLC.

Sub code	Subject Name	Teaching Scheme (Hrs)			Credits Assigned			
		Theory	Pract	Tut.	Theory	Pract.	Tut.	Total
ISC702	Biomedical Instrumentation	4	2	-	4	1	-	**5**

Sub code	Subject Name	Examination Scheme							
		Theory (out of 100)				Term Work	Pract. and oral	Oral	Total
		Internal Assessment (out of 20)			End sem Exam				
		Test 1	Test 2	Avg					
ISC702	Biomedical Instrumentation	20	20	20	80	25	-	25	**150**

Subject Code	**Subject Name**	**Credits**
ISC702	**Biomedical Instrumentation**	**5**
Course Objectives	• To make students understand the Identification, classification, and working principle of various Biomedical Instruments used for Bio-potential measurement and application of these instruments in diagnosis, therapeutic treatment and imaging fields.	
Course Outcomes	The students will be able to • Identify various Bio-potential and their specifications in terms of amplitude and frequency. • Understand principle and working of various Biomedical Instruments for diagnosis applications. • Decide the applications of therapeutic instruments for treatment purpose. • Understand applications of imaging instruments and the modalities involved in each technique.	

Module	**Topics**	**Hrs.**
1	**Bio-Potential and Measurement:** Structure of Cell, Origin of Bio-potential, electrical activity of cell their characteristic and specifications. Measurement of RMP and AP. Electrode-Electrolyte interface and types of bio-potential electrodes.	**08**
2	**Physiological Systems and Related Measurement:** Respiratory system- Physiology of respiration and measurements of respiratory related parameters. Cardiovascular system- Structure of Heart, Electrical and Mechanical activity of Heart, ECG measurements and Cardiac arrhythmias. Nervous system- Nerve cell, neuronal communication, nerve-muscle physiology, CNS, PNS. Generation of EEG and its measurement. Normal and abnormal EEG, evoked potential and epilepsy. Muscular system- Generation of EMG signal, specification and measurement.	**12**

	Design of ECG amplifier.	
3	**Cardiovascular Measurement:** Blood Pressure- Direct and Indirect types, Blood Flow- Electromagnetic and Ultrasonic types, Blood Volume- Types of Plethysmography. (Impedance, Capacitive and Photoelectric), Cardiac Output- Flicks method, Dye-dilution and Thermo-dilution type, Heart sound measurement.	**08**
4	**Life support Instruments:** Pacemaker- Types of Pacemaker, mode of pacing and its application, Defibrillator- AC and DC Defibrillators and their application, Heart Lung machine and its application during surgery, Haemodialysis system and the precautions to be taken during dialysis.	**08**
5	**Imaging Techniques:** X-Ray- Generation, X-ray tube and its control, X-ray machine and its application, CT Scan- CT Number, Block Diagram, scanning system and application, Ultrasound Imaging- Modes of scanning and their application, MRI- Concepts and image generation, block diagram and its application.	**10**
6	**Significance of Electrical Safety:** Physiological effects of electrical current, Shock Hazards from electrical equipment and methods of accident prevention.	**02**

* **One Hospital Visit is recommended for imaging Instruments.**

List of Experiments:

1. Demonstration and working of instruments like EMG, EEG and ECG.
2. Study of electrodes for various applications.
3. To measure Blood pressure by indirect method.
4. To study Pacemaker and various waveforms or Design and implement Pacemaker CKT.
5. To study Defibrillator and voltage waveforms or Design and implement Defibrillator CKT.
6. Design of ECG amplifier and testing of gain frequency response with weak input signal.
7. To design and implement ECG signal conditioning circuits with different parameter.
8. To design and implement EMG quantification Circuit.
9. Testing and study of Hemodialysis, Heart/Lung machine models based.
10. ECG simulation on PC.
11. ECG Simulation using Microcontroller.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 question need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Practical/Oral Examination:
Oral examination will be based on entire syllabus and experiments performed.

Term Work:

Term work shall consist of minimum eight experiments.
The distribution of marks for term work shall be as follows:

Laboratory work (Experiments)	: 10 Marks
Laboratory work (Assignments / journal)	: 10 Marks
Attendance (Theory and Practical)	: 05 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Assessment:

Internal Assessment consists of two tests out of which, one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Text Books:

1. Leslie Cromwell, "Biomedical Instrumentation and Measurements", 2nd Edition, Pearson Education, 1980.
2. John G. Webster, "Medical Instrumentation", John Wiley and Sons, 4th edition, 2010.
3. R. S. Khandpur, "Biomedical Instrumentation", TMH, 2004

Reference Books:

1. Richard Aston, "Principles of Biomedical Instrumentation and Instruments", PH, 1991.
2. Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment Technology", PHI/Pearson Education, 4th edition, 2001.
3. John E Hall, Gyton's Medical Physiology, 12th edition, 2011

Sub code	Subject Name	Teaching Scheme (Hrs)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ISC703	Advanced Control System	4	2	-	4	1	-	5

Sub code	Subject Name	Examination Scheme							
		Theory(out of 100)				Term Work	Pract. and oral	Oral	Total
		Internal Assessment (out of 20)			End sem Exam				
		Test 1	Test 2	Avg.					
ISC703	Advanced Control System	20	20	20	80	25	25	-	150

Subject Code	**Subject Name**	**Credits**
ISC703	**Advanced Control system**	5
Course Objectives	• To make students understand the concept of non linear control, Internal Model Control and Optimal Control. • To Study the stability of Non Linear and Linear systems .	
Course Outcomes	The Students will be able to • Linearize the non linear physical systems. • Study the non linear system behavior by phase plane and describing function methods • Study the stability of linear and nonlinear systems by Lyapunov method. • Design IMC with Uncertainty and Disturbances.	

Module	**Content**	**Hours**
Prerequisite	Modeling of linear systems, Simulation of system, System stability through transient response and frequency response techniques. Superposition theorem for differentiating linear and nonlinear systems.	
1	**Introduction** Norms for Signals and Systems, Input-Output relationships, **Nonlinear Control Systems** Definition of nonlinear systems, Difference between linear and nonlinear systems, characteristics of nonlinear systems, Common physical nonlinearities **Linearization Methods** Jacobian Linearization, Concept of relative degree, Feedback linearization for systems with no internal dynamics.	8

2.	**Phase-plane Analysis** Phase-plane Analysis, Basic concepts, phase-trajectories, phase portrait, Constructing phase portraits-Analytical Methods, Graphical Method - Delta Method, Determining Time from Phase Portraits, Singular points and their classification, limit cycles and behavior of limit cycles.	10
3.	**Describing Function Analysis** Describing Function Fundamentals, Describing Functions of saturation, dead zone, relay and their combinations, Stability analysis of nonlinear systems via describing function method .	8
4.	**Lyapunov Stability Analysis** Stability of equilibria, Asymptotic stability graphically , Lyapunov stability theorems, Stability analysis of linear systems, Construction of Lyapunov functions using Krasovskii method and variable gradient method.	10
5.	**Internal Model Control** Introduction to Model-Based Control, Open loop controller Design, Model Uncertainty and Disturbances, Development of IMC structure, IMC-Based PID Controller Design	8
6	**Optimal Control** Problem Formulation, Continuous linear regulator problem (LQR),Solution via Control Algebraic Riccati Equation (CARE**)**	4

List of Laboratory Experiments

- Nonlinear Control System and Analysis

a) Construct the trajectory for system represented by second order differential equation and for any initial condition by using Delta Method.
b) Draw the trajectory for the system with nonlinear element – relay, saturation, etc. for any initial condition and step input by using Delta Methods.
c) Study behavior of limit cycle with the help of Vander Pol's equation.
d) Derivation of DF for nonlinearities – relay with saturation, relay with dead-zone, dead-zone and saturation etc.
e) Investigate the stability of system with nonlinearities – relay, saturation, dead-zone and existence of limit cycle using DF technique.

- Lyapunov Stability Analysis

a) Verify Sylvester theorem for the definiteness of the Lyapunov Function.
b) Determine the stability of the system and construct the Lyapunov function for Linear Time Invariant system.
c) By using Krasovskii method determine the stability of the system and construct the Lyapunov function.
d) By using Variable Gradient method determine the stability of the nonlinear system.

- Internal Model Control

a) Effect of filter tuning parameter on step response of the first and second order systems.
b) Design of IMC controller for a system subject to step input.
c) Design of IMC controller for a system subject to ramp input.
d) Design of IMC based PID controller.
e) Design of IMC controller for delay and non-minimum phase systems.

- Optimal Control

a) Obtain control for the second order system using given Quadratic Function.
b) Obtain control for the second order system via solution of Riccati Equation.

Theory Examination:

1. Question paper will consist of total 6 questions carrying 20 marks each.
2. Only 4 questions need to be attempted.
3. Q.1 will be compulsory and based on the entire syllabus.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.
6. No questions should be asked from the prerequisite module.

Term work:

Term work consists of minimum eight experiments, two case studies and a written test. The distribution of the term work shall be as follows,

Laboratory work (Experiments and Journal)	:15marks
Test (at least one)	:10 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

Assessment:

Internal Assessment consists of two tests out of which, one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Text Books:

1. K. Ogata, *Modern Control Engineering,* Prentice Hall of India, 4th edition, 2002.
2. I. J. Nagrath and M. Gopal, *Control System Engineering*, 3rd Edition, New Age International (P) Ltd., Publishers - 2000.

Reference Books:

1. Slotine, Li - “Applied Nonlinear Control”
2. M. Gopal, "Modern Control System Theory", Wiley Eastern Ltd., New Delhi.
3. John Doyle, Bruce Francis, Allen Tannenbaum, “Feedback Control Theory”.
4. Pierre R. Belanger, “Control Engineering” Saunders college Publishing.
5. Donald E. Kirk, “Optimal Control Theory- An Introduction,”.

	control functions, continuous processes, discrete processes, and mixed processes. Automation hierarchy – large control system hierarchy, data quantity & quality and hierarchical control. Control system architecture – evolution and current trends, comparison of different architectures.	
2	**Programmable Logic Controller** **Hardware** Evolution of PLC, Definition, functions of PLC, Advantages, Architecture, working of PLC, Scan time, Types & Specifications. DI-DO-AI-AO examples and ratings, I/O modules, local and remote I/O expansion, special purpose modules, wiring diagrams of different I/O modules, communication modules, Memory & addressing- memory organization (system memory and application memory), I/O addressing, hardware to software interface. **Software** Development of Relay Logic Ladder Diagram, introduction to PLC Programming, programming devices, IEC standard PLC programming languages, LD programming- basic LD instructions, PLC Timers and Counters: Types and examples, data transfer & program control instructions, advanced PLC instructions, PID Control using PLC. **Case study:** PLC selection and configuration for any one process applications**.**	14
3	**Distributed Control System** (**DCS**) Introduction to DCS. Evolution of DCS, DCS flow sheet symbols, architecture of DCS. Controller, Input and output modules, Communication module, data highway, local I/O bus, Workstations, Specifications of DCS. Introduction of Hierarchical control of memory: Task listing, Higher and Lower computer level task. Supervisory computer tasks DCS configuration. Supervisory computer functions, Control techniques, Supervisory Control Algorithm. DCS & Supervisory computer displays, advanced control Strategies, computer interface with DCS. DCS. System integration with PLCs computer: HMI, Man machine interface sequencing, Supervisory control, and integration with PLC, personal computers and direct I/O, serial linkages, network linkages, link between networks. Introduction to DCS Programming, Function Block Diagram method for DCS programming.	12
4	**Supervisory Control and Data Acquisition (SCADA)** SCADA introduction, brief history of SCADA, elements of SCADA. Features of SCADA , MTU- functions of MTU, RTU- Functions of RTU, Protocol Detail SCADA as a real time system Communications in SCADA- types &	10

	methods used, components, Protocol structure and Mediums used for communications SCADA Development for any one typical application Programming for GUI development using SCADA software.	
5	**Database and Alarm Management, MES, ERP** Database management, Philosophies of Alarm Management, Alarm reporting, types of alarms generated and acceptance of alarms. MES, Integration with enterprise system.	04
6	**Safety Instrumented System (SIS)** Need for safety instrumentation- risk and risk reduction methods, hazards analysis. Process control systems and SIS. Safety Integrity Levels (SIL) and availability. Introduction to the international functional safety standard IEC61508	04

List of Experiments:

1. Manipulation of sensor signals by the PLC to drive various end effectors such as pnematic/electric/hydraulic
2. 4 PLC programs for process control applications
3. DCS programming using Function block diagram method
4. GUI development for any one application using SCADA software.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 question need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Oral Examination:
Oral examination will be based on entire subject

Term Work:
Term work shall consists of minimua 4 experiments and four assignments.
The distribution of marks for term work shall be as follows:
Laboratory work (Experiments) : 10 Marks
Laboratory work (programs / journal) : 10 Marks
Attendance (Theory and Practical) : 05 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Assessment:

Internal Assessment consists of two tests out of which, one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Text Books:

1 Samuel M. Herb , " Understanding Distributed Processor Systems for Control", ISA Publication.

2. Thomas Hughes, "Programmable Logic Controller", ISA Publication.

3. Stuart A. Boyer, "SCADA supervisory control and data acquisition", ISA Publication.

4. Gruhn and Cheddie, "Safety Shutdown Systems" – ISA, 1998,

Reference Books:

1. Poppovik Bhatkar, "Distributed Computer Control for Industrial Automation", Dekkar Publication.
2. S.K.Singh, "Computer Aided Process Control", Prentice Hall of India.
3. Krishna Kant, "Computer Based Process Control", Prentice Hall of India
4. N.E. Battikha, "The Management of Control System: Justification and Technical Auditing", ISA.
5. Gary Dunning, "Introduction to Programmable Logic controller", Thomas Learning, edition, 2001.
6. John. W.Webb, Ronald A Reis, "Programmable Logic Controllers – Principles and Applications", 3rd edition, Prentice Hall Inc., New Jersey, 1995.
7. Bela G. Liptak "Instrument engineers handbook- Process control" Chilton book company- 3rd edition.
8. D.J. Smith & K.G.L. Simpson, "Functional Safety: A Straightforward Guide to IEC61508 and Related Standards", -Butterworth-Heinemann Publications.

Sub code	Subject Name	Teaching Scheme (Hrs)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ISE7051	Advanced Embedded Systems	4	2	-	4	1	-	5

Sub code	Subject Name	Examination Scheme							
		Theory(out of 100)							
		Internal Assessment (out of 20)			End sem Exam	Term Work	Pract. and oral	Oral	Total
		Test 1	Test 2	Avg.					
ISE7051	Advanced Embedded Systems	20	20	20	80	25	-	25	150

Subject Code	**Subject Name**	**Credits**
ISE7051	**Advanced Embedded systems**	**5**
Course Objectives	• To make students understand the 32bit processors and higher architectures and configuration. • Use of Real Time systems and there design in Instrumentation systems.	
Course Outcomes	The students will be able to • Designing using ARM processors • Use Real time software for designing instrumentation systems • Design with configurable hardware systems	

Module	**Topics**	**Hrs.**
1	**ARM Processor** Introduction to ARM7 & ARM9 Architecture ARM 7: ARM-THUMB mode, programming model, instruction set, and programming.	06
2	**LPC2148 architecture** Development tools for High level language-C,Device programming & ISP. On-Chip Device peripherals RTC programming On-chip ADC programming for Signal Sampling Watchdog timer	15

	Timer programming- Timer / Capture mode Serial port programming for PC communication PWM Signal generation Idle and Power down mode Interrupt handling Universal serial Bus Interfacing peripherals	
3	**System Design** **I**nstrumentation System design with ARM processor (Instrumentation Hardware design to be at Block level only) Eg: Data acquisition systems PID Heater controller etc	06
4	**FreeRTOS** FreeRTOS design,Task & Scheduler API's,Queue API,Semaphore API Software Timer API	08
5	**Designing with FreeRTOS** LPC2148 port and design using FreeRTOS	08
6	**Configurable Hardware** Introduction and Architecture of PAL, PLA, CPLD, FPGA. Comparison of above devices & application areas. Advantages of above. Introduction to development tools. Project development cycle. Introduction of Hardware description Languages and its Features. Introduction to ASIC, PSOC.	05

List of Experiments:

2 application case studies, & Experiments mentioned in the Unit 2 & 4 above (Use of RTOS is recommended wherever applicable).
A seminar presented by a group of about three students on latest state-of-the-art technologies in Embedded systems: Processor families and trends, Embedded Devices like Digital Camera, Cruise Controller, Mobile phone, Smartcard based Applications & Systems, Point of Sale terminals, DVD Systems, CPLD, FPGA, VHDL, Verilog etc., Various RTOSs like VxWorks, RTLinux, pSOS, Handheld OS- Symbian etc., Selection criteria & development tools For various processors like Cortex-M3, ARM9.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 question need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weight age of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Practical/Oral Examination:
Practical/Oral examination will be based on entire syllabus.

Term Work:
Term work shall consist of minimum eight experiments.
The distribution of marks for term work shall be as follows:

Laboratory work (Experiments)	: 10 Marks
Laboratory work (programs / journal)	: 10 Marks
Attendance (Theory and Practical)	: 5 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Assessment:

Internal Assessment consists of two tests out of which, one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Reference Books:

1. Rajkamal, Embedded Systems Architecture Programming and Design, McGraw Hill, Second Edition.
2. Dr.K.V.K.K.Prasad, Embedded /Real Time Systems: Concept, Design and Programming, DreamTech Press.
3. John F. Wakerly, Digital Design Principles and Practices 4th Edition, Pearson Prentice Hall.
4. Embedded Systems: An Integrated Approach by Lyla B.Das
5. FreeRTOS manual
6. LPC2148 Datasheet

Sub Code	Subject Name	Teaching Scheme (Hrs)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical/ oral	Tutorial	Total
ISE7052	Image Processing	4	2	-	4	1	-	5

Sub Code	Subject Name	Examination Scheme							
		Theory(Out of 100)				Term Work	Prac and Oral	Oral	Total
		Internal Assessment (out of 20)			End Sem Exam				
		Test-I	Test-I	Avg					
ISE7052	Image Processing	20	20	20	80	25	-	25	150

Subject Code	**Subject Name**	**Credits**
ISE7052	Image Processing	5
Course Objectives	• The principle of the syllabus is to give an introduction to basic concepts and methodologies for digital image processing .The students are expected to develope a foundation that can be used as the basis for further study and research in this field. • The syllabus gives great emphasis on basic principles as well as more advanced techinques for image enhancement,segementation, morophological operations etc	
Course Outcomes	• Student will be able to understand the basic concepts and methodologies for digital image processing. • Students will be able to study and program advanced techniques for image enchancement ,segementation morophological operations etc.	

Module	**Contents**	**Hours**
1	**Introduction:** Definition of image, generation of image, steps in image processing, elements of digital image processing systems, image enhancements, restoration and analysis. **Digital Image Fundamentals:** Elements of visible perception, image model, sampling and quantization, relationships between pixels, imaging geometry.	8

2	**Image Transforms:** Introduction to D.F.T., 2-D.F.T., F.F.T., other seperable image transforms (walsh, hadamard, discrete cosine, haar, slant, KL)	8
3	**Image Enhancements:** Point operations, histogram modeling, spatial filtering-smoothing, sharpening, low pass, high pass, homomorphic filtering. **Image Restoration:** Image observation models, inverse and wiener filtering, F.I.R. wiener filters, filtering using image transforms, least squares filters, generalized inverse, S.V.D. and interactive methods, recursive filtering, causal models, digital processing of speckle images, maximum entropy restoration.	17
4	**Image Segmentation:** Detection of discontinuities, age linking and boundary detection, thresholding, region oriented segmentation, use of motion in segmentation.	5
5	**Image Data Compression**: Introduction, pixel coding, predictive techniques (PCM, DPCM, etc), transform coding theory of images, hybrid coding and vector DPCM.	5
6	**Morphological Image Processing:** Preliminaries,erosion and dilation,opening and closing,the Hit-or-Miss transformation,some morphological algorithms Like thinning,thickening,skeletons	5

LIST OF EXPERIMENTS:

1. Program for 2-D convolution.
2. Image rotation scaling and translation.
3. Program for 2-D correlation.
4. Program for 2-D F.F.T.
5. Program for Discrete cosine transform.
6. Program for K L transform.
7. Program for Histogram equalization & Histogram specification.
8. Program for Mask operation (Spatial filtering).
9. Program for edge detection.
10. Program for Thresholding.
11. Function for determining boundary descriptors, like boundary length and curvature.
12. Program for opening and closing operations.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4

to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Practical/Oral Examination:
Practical/Oral examination will be based on entire syllabus.

Term work:
Term work shall consist of minimum eight experiments.
The distribution of marks for term work shall be as follows:

Laboratory work (Experiments)	: 10 Marks
Laboratory work (programs / journal)	: 10 Marks
Attendance (Theory and Practical)	: 05 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Assessment:
Internal Assessment consists of two tests out of which, one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.
End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Text Books:

1. R. C. Gonzalez, "Image Processing" Pearson Education 2nd edition, 1999.
2. A. K. Jain, "Fundamental of Digital Image Processing", PHI 2nd edition, 1995.
3. W. K. Pratt, "Digital Image Processing", John Wiley and Sons, 1994.

Reference Books:

1. C. Phillips, "Image Processing in C", BPB Publication, 1995.
2. B. Chanda, D. Dutta Majumdar, "Digital Image processing", PHI, 2000.
3. Emmauel C. Ifeachor and Barry W. Jervis, "Digital Signal Processing", Pearson Education, 2nd edition, 2000.
4. Don Pearson, "Image Processing" (The ESSEX series in Telecommunication and information systems, McGraw Hill International ELTL engg. Series), 1991.
5. Johnny Johnson, "Introduction to DSP", PHI - 1996.
6. Proakis, "DSP", PHI 1997.
7. Rabnier Gold, "Theory and Application of DSP", PHI, 1996.
8. Milan Sonka, Vaclav Hlavac, "Image Processing analysis and machine vision",Thomson Learning, 2nd edition, 1999

Sub code	Subject Name	Teaching Scheme (Hrs)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract	Tut.	Total
ISE7053	Functional Safety	4	-	2	4	---	1	5

Sub code	Subject Name	Examination Scheme							
		Theory(out of 100)							
		Internal Assessment (out of 20)			End sem Exam	Term Work	Pract. and oral	Oral	Total
		Test 1	Test 2	Avg.					
ISE7053	Functional safety	20	20	20	80	25	-	25	150

Subject Code	**Subject Name**	**Credits**
ISE7053	**Functional Safety**	**5**
Course Objectives	To make the students aware of basic concepts of safety instrumented system, standards and risk analysis techniques.	
Course Outcomes	The students will be able to • Understand the role of Safety instrumented system in the industry. • Identify and analyse the hazards, • Select the Safety integrity level.	

Module	**Topics**	**Hrs.**
1	**Introduction :** Safety Instrumented System (SIS) - need, features, components, difference between basic process control system and SIS, Risk: how to measure risk, risk tolerance, Safety integrety level,safety instrumented functions. Standards and Regulation – HSE-PES, AIChE-CCPS, IEC-61508, ANSI/ISA-84.00.01-2004 (IEC 61511 Mod) & ANSI/ISA – 84.01-1996.9, NFPA 85.10, API RP 556,11 , API RP 14C,11, OSHA (29 CFR 1910.119 – Process Saftey Management of Highly Hazardous Chemicals),	06
2	**Safety life cycle:** Standards and safety life cycle, analysis phase, realisation phase, operations phase Allocation of Safety Functions to Protection Layers, Develop Safety Requirements Specifications, SIS Design and Engineering, Installation, Commissioning and Validation, Operations and Maintenance, Modification, De-commissioning.	06
3	Process Control – Active / Dynamic , Safety Control – Passive / Dormant, Demand Mode vs. Continuous Mode, Separation of Control and Safety Systems - HSE-PES, AIChE-CCPS, IEC-61508, Common Cause and Systematic or Functional Failures, Protection Layers : prevention and mitigation layers, SIS Technologies: Pneumatic Systems, Relay Systems, Solid State Systems, Microprocessors /	08

	PLC (Software based) Systems	
4	**Rules of Probability:** Assigning probability to an event, types of events and event combination, combining event probabilities, fault tree analysis, failure rate and probabiuity, simplifications and approximations.	08
5	**Process Hazard Analysis:** Consequence analysis: Characterisation of potential events, dispersion, impacts, occupancy considerations, consequence analysis tools. Likelihood analysis: estimation and statistical analysis, fault propagation, event tree analysis and fault tree analysis, Quantitative layer of protection analysis: multiple initiating events, estimating initiating event frequencies and IPL failure probabilities	12
6	**Determining the Safety Integrity Level (SIL) :** Evaluating Risk, Safety Integrity Levels, SIL Determination Method : As Low As Reasonably Practical (ALARP), Risk matrix, Risk Graph, Layers Of Protection Analysis (LOPA)	08

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 question need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Practical/Oral Examination:
Practical/Oral examination will be based on entire syllabus.

Term Work:
Term work shall consist of minimum six assignments and two assignments with EXCEL.
The distribution of marks for term work shall be as follows:

Laboratory work	: 10 Marks
Laboratory work (programs / journal)	: 10 Marks
Attendance	: 05 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Assessment:

Internal Assessment consists of two tests out of which, one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Reference Books:

1. Paul Gruhn and H Jarry L. Cheddie," Safety Instrumented systems: Design, Analysis and Justification", ISA , 2nd edition, 2006
2. Dr. Eric W Scharpf, Heidi J Hartmann, Harlod W Thomas, " Practical SIL target selection : Risk analysis per the IEC 61511 safety Lifecycle", exida,2012.
3. Ed Marszal, Eric W Scharpf , "Safety Integrity Level Selection", ISA.

Sub code	Subject Name	Teaching Scheme (Hrs)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract	Tut.	Total
ISE7054	Process Modeling & Optimization	4	-	2	4	---	1	5

Sub code	Subject Name	Examination Scheme							
		Theory(out of 100)				Term Work	Pract. and oral	Oral	Total
		Internal Assessment (out of 20)			End sem Exam				
		Test 1	Test 2	Avg.					
ISE7054	Process Modeling & Optimization	20	20	20	80	25	-	25	150

Subject Code	**Subject Name**	**Credits**
ISE7054	**Process Modeling & Optimization**	05
Course Objectives	• To make students understand the basic approach to the problem of mathematical modeling and identifying the variables by using direct methods. • To translate a descriptive statement of the design problem into a mathematical statement for optimization. • To use numerical methods for solving engineering optimization problems.	
Course Outcomes	Students will be able to • formulate mathematical models of the complex engineering systems. • to use an optimization algorithm to solve linear and nonlinear optimization problems. • explain the kind of interaction possible with an optimization algorithm.	

Module No.	**Contents**	**Hours**
1.	**Mathematical Modeling** Definition of Mathematical model, Classifications of Models, How to build a model, Use of mathematical models and principles of formulation, Fundamental laws: Continuity equations, Energy equation, Equations of motion, Chemical kinetics, Modeling of CSTR (isothermal, no-isothermal, constant holdup, variable holdup).	07

2	**Process Identification** Direct Methods: Time-Domain "Eyeball" Fitting of Step test data, Direct Sine-Wave Testing, Pulse Testing, Step Testing, ATV Identification, Least-Squares Method, State Estimator.	06
3.	**Introduction to Optimization:** Definition and meaning of optimization, need of optimization, conventional versus optimum design process, optimization problem formulation – statement of an optimization problem, terminology, design vector, objective function, design constraints, constraint surface, Iteration, convergence, classification of optimization problem, engineering applications of optimization.	06
4.	**Classical Optimization Techniques:** Fundamental concepts- local and global minima, local and global maxima, quadratic form, necessary and sufficient condition of single and multivariable optimization with no constraints, multivariable optimization with equality and inequality constraints(Kuhn-Tucker condition), Lagrange Theorem.	10
5.	**Linear Programming :** Definition of linear programming problem (LPP), standard form of LPP, terminology, basic concepts, Simplex Algorithm and flowchart, simplex method, two-phase simplex method, Duality in LPP	09
6.	**Numerical Methods for Unconstrained Optimum Design:** General algorithm for unconstrained minimization methods, rate of convergence, unimodal and multimodal function ,reduction of a single variable, one dimensional minimization methods- Equal Interval method, Golden section search method, Polynomial Interpolation : Quadratic Interpolation method, Cubic Interpolation method, Gradient of a function, properties of gradient vector, Steepest Descent, Conjugate gradient (Fletcher-Reeves).	10

Assignments:
Each student shall do at least **Two** assignments on Module No. 1, **One** assignment on Module No. 2, **Two** Assignments on Module No. 3 and **Two** assignments on Module No. 4, 5 & 6 each.

Theory Examination:

1. Question paper will consist of total 6 questions of 20 marks each.
2. Only 4 questions need to be solved.
3. Q.1 will be compulsory and based on the entire syllabus.
4. Remaining questions will be mixed in nature.
5. In question paper, weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Oral Examination:
Oral examination will be based on entire subject.

Term work:
Term work consists of minimum ten assignments.
The distribution of the term work shall be as follows:

Laboratory work (Assignments/Experiments)	:10 Marks
Laboratory work (Journal)	:10 Marks
Attendance (Theory and Practical)	:05 Marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

Assessment:

Internal Assessment consists of two tests out of which, one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Text Books:

1. S. S. Rao, "Optimization", 2nd edition, New Age International (P) Ltd., Publishers, New Delhi, 1995.
2. Jasbir S. Arora, "Introduction to Optimum Design", ELSEVIER, Academic Press, USA – 2004.
3. T. E. Edger and D. M. Himmeblaue, "Optimization of Chemical Processes", McGraw Hill International Editions, 1989.
4. William L. Luyben, "Process Modeling, Simulation, And Control For Chemical Engineers" McGraw-Hill Publishing Company,1990.

Reference Books:

1. Kalyanmoy Deb, "Optimization For Engineering Design", Prentice Hall of India (P) Ltd., New Delhi, 1998.
2. Ashok D. Belegundu, "Optimization concepts and applications in Engineering", Pearson Education, 2002.
3. Hamby A. Taha, "Operation Research", Pearson education - 2007.

Sub code	Subject Name	Teaching Scheme (Hrs)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ISE7055	Wireless Communication	4	2	-	4	1	-	5

Sub code	Subject Name	Examination Scheme							
		Theory(out of 100)				Term Work	Pract. and oral	Oral	Total
		Internal Assessment (out of 20)			End sem Exam				
		Test 1	Test 2	Avg.					
ISE7055	Wireless Communication	20	20	20	80	25	-	25	150

Subject Code	**Subject Name**	**Credits**
ISE7055	**Wireless Communication**	**5**
Course Objectives	• To make students understand concept of Wireless Communication in real time process control application.	
Course Outcomes	The students will be able to • Basics of Wireless Communication Systems • Understands Wireless Transceivers and Advanced Transceivers • Understands Wireless Application Protocol • Understands Different Wireless trends in Industry	

Module	**Topics**	**Hrs.**
1	**Introduction to Wireless Communication:-** History, Types of services: Broadcast, paging, cellular Telephony, cordless telephony, Wireless LAN (WLAN), Ad Hoc Network, Personal Area Network (PAN), Wireless Sensors networks Bandwith concept, Technical challenges of Wireless Communication: Multipath propagation, spectrum limitations Present scenario in Wireless Communication Systems	10
2	**Wireless Transceivers:** Quadrature Phase shift keying, differential quadrature phase shift keying, offset quadrature phase shift keying, minimum phase shift keying, Gaussian minimum shift keying, power spectrum and error performance in fading channels.	08
3	**Advanced Transceivers:** Spread spectrum systems TDMA, SDMA, CDMA, FDMA principle, power control, effects of multipath propagation on CDMA, OFDM, DSSS and FHSS.	06

4	**Wireless Application Protocol (WAP):** Introduction, WAP and the World Wide Web (WWW), Introduction to Wireless Application Protocol, The WAP Programming Model, WAP Architecture, WAP Advantage and Disadvantages, Application of WAP, imode, imode versus WAP	08
5	**Application of Wireless Communication:** Bluetooth, Ultra Wide Band, Zigbee, WiFi, Introduction to 3G & 4G	06
6	**WirelessHART:** WirelessIntroduction *Wireless*HART Security Overview *Wireless*HART Adaptor *Wireless*HART Gateway Co-Existence of *Wireless*HART with other Wireless Technologies Control with *Wireless*HART System redundancy with *Wireless*HART Peer-to-Peer Communication with *Wireless*HART **Introduction to Wireless Foundation Fieldbus**	10

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 question need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Practical/Oral Examination:
Practical/Oral examination will be based on entire syllabus.

Term Work:
Term work shall consist of minimum eight Assignments based on above topics.
The distribution of marks for term work shall be as follows:
Laboratory work (Assignments/Experiments) :10 Marks
Laboratory work (Journal) :10 Marks
Attendance (Theory and Practical) :05 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Assessment:

Internal Assessment consists of two tests out of which, one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Text Books:

1. Theodore S. Rappaport, "Wireless Communications Principles and Practice", PEARSON, 4th impression, 2011
2. Andreas F. Molisch, "Wireless Communications", WILEY-INDIA, 2006
3. Vijay K. Garg, "Wireless Communications and Networking", Morgan Kaufmann Publishers,2009
4. http://www.hartcomm.org

Reference Books:

1. Andrea Goldsmith, "Wireless Communications", CAMBRIDGE UNIVERSITY PRESS, 2005
2. Davis Tse, Pramod Viswanath, "Fundamentals of Wireless Communication", CAMBRIDGE UNIVERSITY PRESS, 1st ed., 2005
3. Xiaodong Wang, H. Vincent Poor, "Wireless Communication Systems", PEARSON, 1st ed., 2004
4. Upena Dalal, "Wireless Communication", OXFORD UNIVERSITY PRESS, 2nd impression, 2010
5. NIIT, "Basics of Wireless Communications", Prentice-Hall of India,2004
6. William Stallings, "Wireless Communications and Networks", PEARSON, 5th ed., 2004
7. T.L. Singal, Wireless Communications, Tata McGraw Hill ,2010

Sub code	**Subject Name**	Teaching Scheme (Hrs)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ISC801	**Digital control system**	4	2	-	4	1	-	5

Sub code	Subject Name	Examination Scheme							
		Theory(out of 100)				Term Work	Pract. and oral	Oral	Total
		Internal Assessment (out of 20)			End sem Exam				
		Test 1	Test 2	Avg.					
ISC801	Digital control System	20	20	20	80	25	25	-	150

Subject Code	**Subject Name**	**Credits**
ISC801	**Digital control System**	**5**
Course Objectives	• To equip the students with the basic knowledge of discretization. • To study the stability analysis of digital control system. • To study the canonical forms of digital control systems • To determine steady state performance of Digital control systems. • To design the controller and observer for digital control systems. • To study PID discrete controller	
Course Outcomes	The students will be able to • Understand mathematical models of linear discrete-time control systems using transfer functions and state-space models. • Analyze transient and steady-state behaviours of linear discrete-time control systems. • Determine whether performance of linear discrete-time control systems meet specified design criteria. • Design controllers and observers for linear discrete-time control systems so that their performance meet specified design criteria. • Design PID controllers.	

Topics	**Contents**	**Hours**
01	**Introduction** Block diagram of Digital Control System, Advantages &limitations of Digital Control System, comparison of continuous data & discrete data control system, Examples of digital control system, data conversion and quantization, sampling period considerations, sampling as impulse modulation, sampled spectra &aliasing, Reconstruction of analog signals, zero order hold, first order hold.	12

	principles of discretization- impulse invariance, finite difference approximation of derivatives, rectangular rules for integration, Bilinear transformation, Mapping between s-plane & z-plane.	
02	**Representation of digital control system** Linear difference equations, pulse transfer function, input output model, examples of first order continuous and discrete time systems, Signal flow graph applied to digital control systems.	04
03	**Stability of digital control system in z-domain and Time domain analysis** Jury's method, R.H. criteria, Comparison of time response of continuous data and digital control system, steady state analysis of digital control system, Effect of sampling period on transient response characteristics.	06
04	**State space analysis** Discrete time state equations in standard canonical forms, similarity transformation, state transition matrix, solution of discrete time state equation, Discretization of continuous state space model &its solution.	06
05	**Pole placement and observer designs** Concept of reachability, Controllability, Constructability & Observability, Design of controller via Pole placement method, dead beat controller design, concept of duality, state observer design, Concept of Multi rate output feedback (MROF) based state estimation.	10
06	**Transfer Function Approach to Controller Design** Control Structures, Internal Stability and Realizability, Internal Model Principle and System Type, Well Behaved Signals, Solving Aryabhatta's Identity. **Proportional, Integral, Derivative Controllers**-Discretization of PID Controllers, Pole Placement Controller with Performance Specifications, Implementation of Unstable Controllers.	10

List of Laboratory Experiments:

1. To determine response of zero order hold and first order hold using Simulink of MATLAB or any other suitable software.
2. Mapping from S- plane to Z-plane analytically and verification using MATLAB or any other suitable software.
3. Discretization of continuous data system using i) Step invariance method, ii) Impulse invariance method, and iii) Bilinear transformations, analytically and verification using MATLAB or any other suitable software.
4. To represent given system in different canonical forms, analytically and verification using MATLAB or any other suitable software.
5. To determine pulse transfer function of a given system analytically and its verification using MATLAB or any other suitable software.
6. Determination of state transition matrix analytically and its verification using MATLAB or any other suitable software.
7. To check controllability and obser vability of a given system analytically and verify the result using MATLAB or any other software.
8. To plot pole-zero map of a discrete system and comment on response and stability.
9. To design the controller using .
   i. Transform method

ii. Ackerman's Formula

Analytically and verification using MATLAB or any other suitable software.

10. To design an observer using .
    i. Transform Method
    ii. Ackerman's Method

Analytically and verification using MATLAB or any other suitable software.

11. To design deadbeat controller and observer using any method analytically and verification using MATLAB or any other suitable software.

Note: The above list is only indicative of possible experiments. Faculty may choose other experiments as well. Care should be taken that the entire syllabus is uniformly covered by the experiments.

Note: Case study1: Developing a state space model of any physical system available in laboratory (Flow loop, pressure loop, level loop etc.) and designing the controller using pole placement method (state space method) and implement the same using simulink of MATLAB or any other suitable software.

Case study2: Developing a pulse transfer function of any physical system available in laboratory (Flow loop, pressure loop, level loop etc.) and designing the controller using transfer function approach (eg. 2-DOF or IMC controller) and implement the same using simulink of MATLAB or any other suitable software.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 question need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Practical/Oral Examination:

Practical/Oral examination will be based on entire syllabus.

Term work

Term work consists of minimum eight experiments, one case study. The distribution of the term work shall be as follows,

Laboratory work (Experiments)	: 10 Marks
Laboratory work (programs / journal)	: 10 Marks
Attendance (Theory and Practical)	: 05 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Assessment:

Internal Assessment consists of two tests out of which, one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on problems.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Text Books:

1. M. Gopal, "Digital Contol and State Variable Methods", Tata McGraw Hill, 2ndEdition, March 2003.
2. K. Ogata, "Discrete Time Control Systems", Pearson Education Inc., 1995.
3. B.C. Kuo, "Digital Control Systems", Saunders College Publishing, 1992.
4. K.M. Moudgalya, “Digital Control”, Wiley-India, Indian Edition, 2009.
5. B. Bandopadhyay and S. Janardhanan, “Discrete Time Sliding Mode Control-A Multirate Output Feedback Approach”, Springer,2005.

Reference Books:

1. Richard J. Vaccaro, "Digital Control", McGraw Hill Inc., 1995.
2. Ashish Tewari, "Modern Control System Design with MATLAB", John Wiley, Feb. 2002.
3. Joe H. Chow, Dean K. Frederick, "Discrete Time Control Problems using
4. MATLAB", Thomson Learning, 1st Edition, 2003.
5. Eronini Umez, "System Dynamics and Control", Thomson Learning, 1999.
6. Franklin Powel, "Digital Control of Dynamic Systems", Pearson Education, 3rd Edition, 2003.
7. Digital Control Systems vol. I & II - Isermann, Narosa publications
8. M. Fadali Antonio Visioli, “Digital control Engineering Analysis & Design”, Academic press, 2nd edition, 2012.

Sub code	Subject Name	Teaching Scheme (Hrs)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ISC 802	Instrumentation Project Documentation & Execution	4	2	-	4	1	-	5

Sub code	Subject Name	Examination Scheme							
		Theory(out of 100)				Term Work	Practical	Oral	Total
		Internal Assessment (out of 20)			End sem Exam				
		Test 1	Test 2	Avg.					
ISC 802	Instrumentation Project Documentation & Execution	20	20	20	80	25	-----	25	150

Subject Code	**Subject Name**	**Credits**
ISC 802	**Instrumentation Project Documentation & Execution**	**5**
Course Objectives	• To provide knowledge of Instrumentation Project & Detailed Engineering techniques in the EPC Consultancy. • The course aims to explain Project Deliverables and Engineering activities of Project Documentation.	
Course Outcomes	• Design & Develop Basic & Detailed Engineering Project Deliverables. • Understand Types of Project Executed in I & C Projects. • Develop skills to Execute and carry different activities in process industry. • Understand Procedures, Guidelines and Thumb Rules for performing Precommissioning activities. • Overall Development of the students by Hands on working Experience.	

Module	**Topics**	**Hrs.**
1	**The Project**: Introduction, predictability, structure, flow and deliverables, Project Planning and Scheduling – project scheduling estimating, configuration management	08
2	**The Project Team**: Customer, designer and constructor	02
3	**Standards used in instrumentation project:** ISA, ANSI, & ASTM, ASME, NFPA, NEMA. **Project Documents.-** Need for Engineering Documents, General Guidelines for Development of Documents, project stage**,** purpose, scope, contents,	18

	references for document, team of creation and users. Major Project Documents: 1) Process Flow Diagram- 2) Piping and Instrumentation diagrams (P&ID) - practical applications. 3) Instrument Index Sheet 4) Instrument specifications sheet- for temperature, pressure, level, flow instruments and control valves. 5) Instrument Location Plan 6) Cable and Tray Routing 7) Cable Schedule 8) JB Schedule 9) Utility requirement 10) Air header schedule 11) Instrument Hook- up diagrams - for control valve, transmitters (DP in liquid service, dry gas service,) Thermocouple, Temperature switch line mounted, flow transmitter, typical level switch, typical instrument air supply, connections for air supply and output. etc. 12) BOM for erection 13) Loop diagrams- pneumatic, electronic and digital data types. 14) Logic diagrams, SAMA Standard	
4	**Systems Integration:** Division of labour, control logic specification, HMI specification Development, System Architecture Design, Network single line diagram generation, Other tasks like control system cabinet design, I/O address assignment (Partitioning)-Hardware & software address, System testing.	8
5	**Procurement, Installation and Commissioning:** **Procurement :** Engineering Procurement procedure, PO format, preparation of tender documents, bids, technical bid evaluation. **Inspection**: Need for Inspection, Documents for Inspection, General Inspection Guidelines, Factory acceptance test (FAT) & Site acceptance test(SAT) , check lists. **Installation of instruments-** Installation standards, installation of instrument junction box, earthing system, cable laying (cable trays, cable types, cable glands), tubing, instrument installation guidelines. **Commissioning:** Pre-commissioning Procedures, check out procedure of control valve, DP transmitter etc. calibration, testing of instruments, operation and maintenance manual, commissioning Procedures. Onsite training.	08
6	Advantages of using software packages for documentation. Overview of documentation software packages used in industry like SPI -Intools.	4

Suggested List of Laboratory Experiments:

1. Study & Development of Equipment Layout Drawing.
2. Study & Development of Process Flow Diagrams.
3. Study & Development of Piping & Instrumentation Diagram.
4. Study & Development of Instrumentation Index.
5. Study ISA specification forms & Development of Instrument Specifications.

6. Study & Development of Instrumentation Location plan.
7. Study & Development of Cable Tray Layout.
8. Study & Development of Sample Hook up drawing & Preparation of BOM.
9. Study & Development of Detailed Engineering schedules.(Project schedule / Cable schedule / JB schedule / AH schedule)
10. Study & Development of Electronic Loop wiring Diagrams.
11. Study & Development of Control Panel wiring Diagrams.
12. Study & Perform pre-commissioning activities.(Hydro Test / Loop checking / Trouble shooting etc)
13. Survey of Instrumentation softwares & Study different features of SPI INTools.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 question need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Oral Examination: 25 Marks
Oral examination will be based on entire subject, Lab work & Consultants visit if any.

Term Work:

Term work shall consist of Laboratory work which includes Minimum study of eight assignments/ Creation of Documents
Other task:(Optional) Visit to any one Engineering consultants office /organizations to understand their Working Environment & submission of Report.
The distribution of marks for term work shall be as follows:

Laboratory work (Assignments)	: 10 Marks
Laboratory work (programs / journal)	: 10 Marks
Attendance (Theory and Practical)	: 05 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Assessment:

Internal Assessment consists of two tests out of which, one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on problems.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Text Books:

1. Andrew Williams,Applied instrumentation in the process industries, 2nd Edition, Vol. 2, Gulf publishing company.
2. Michael D.whitt, Successful Instrumentation and Control Systems Design, ISA Publication.
3. Installation of Instrumentation & Process control systems- EEUA Handbook.

Useful References in PDF form:

Specification forms- ISA-20-1981- ISA Publication
Piping and Instrumentation Diagram Documentation Criteria- Process Industry Practices
Instrumentation Design Criteria-ONGC, Mumbai
Commissioning Procedures -ONGC, Mumbai

Sub code	Subject Name	Teaching Scheme (Hrs)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ISC803	Instrument and System Design	4	-	2	4	-	1	5

Sub code	Subject Name	Examination Scheme							
		Theory(out of 100)				Term Work	Pract. and oral	Oral	Total
		Internal Assessment (out of 20)			End sem Exam				
		Test 1	Test 2	Avg					
ISC803	Instrument and System Design	20	20	20	80	25	-	25	150

Subject Code	**Subject Name**	**Credits**
ISC803	**Instrument and System Design**	**5**
Course Objectives	To make students to understand • Control Valve Sizing concepts and its usual terms for applications like liquid, gas, vapour and flashing fluids. • Control room and Control Panel details • The process of Electronic product design	
Course Outcomes	The students will be able to • Design and Analyse CV Sizing • Identify various Control panels and Control Room details • tDesign of Electronic product.	

Module	**Topics**	**Hrs.**
1	**Design of Transducers:** An overview of static and dynamic performance characteristics of instruments. Selection criteria for flow, temperature transducers. Design considerations for transducers such as thermocouple, RTD, orifice plates, Rota meter. Calibration and installation procedure for thermocouple and RTD	05
2	**Design of Control Valve:** Review of flow equations. Valve selection and sizing for liquid service, gas or vapor service, flashing liquids, mixed phase flow. Control valve noise. Control valve cavitations. Actuator sizing. Design of safety relief valves and rupture discs.	16
3	**Control Panel Design:** Panel selection-size, type, construction and IP classification. GA Diagrams, Power wiring and distribution, Typical wiring diagrams for AI,DI,AO,DO,RTD, and T/C modules. Earthing scheme. Panel ventilation, cooling and illumination. Operating consoles- ergonomics. Wiring accessories- ferules, lugs, PVC ducts, spiral etc. Wire sizes and color coding.	11

	Packing, Pressurized panels- X, Y, and Z Purging for installation in hazardous areas. Ex-proof panels.	
4	**Electronic product design:** System Engineering, ergonomics, phases involved in electronic product design. **Enclosure Design :** Packing and enclosures design guidelines, Grounding and shielding, front panel and cabinet design of an electronic product.	08
5	**Reliability engineering:** Reliability concepts, causes of failures, bath tub curve, Quality and reliability, MTTF, MTBF, and MTTR. Availability and Maintainability. Redundancy and redundant systems.	04
6	**Control Room Design:** Layout and environment.	04

List of Assignments:

1. Assignment on design of transducer
2. Assignment on valve sizing and examples on valve sizing for liquid services
3. Assignment: examples on valve sizing for gas and vapor services
4. Assignment: examples on valve sizing for flashing and mixed flow services
5. Assignment: examples on valve sizing for Noise and Cavitations
6. Assignment: examples on actuator sizing
7. Assignment on control panel design
8. Assignment on control room design, reliability and electronic product design
9. Assignment on electronic product design

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 question need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Practical/Oral Examination:
Oral examination will be based on entire syllabus.

Term Work:
Term work shall consist of minimum eight assignments
The distribution of marks for term work shall be as follows:

Laboratory work (Assignments)	: 10 Marks
Laboratory work (programs / journal)	: 10 Marks
Attendance (Theory and Practical)	: 05 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Assessment:

Internal Assessment consists of two tests out of which, one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on problems.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Text Books:

1. Bela G. Liptak, "Instrument Engineer's Hand Book – Process Control", Chilton Company, 3rd Edition, 1995.
2. Andrew Williams, "Applied instrumentation in the process industries", 2nd Edition, Vol. 1 & 3, Gulf publishing company.

Reference Books:

1. R. W. Zape, "Valve selection hand book third edition", Jaico publishing house,
2. Les Driskell, "Control valve sizing", ISA.
3. Curtis Johnson, "Process Control Instrumentation Technology", PHI /Pearson Education 2002.
4. Kim R Fowler, "Electronic Instrument Design", Oxford University- 1996.
5. Manual on product design: IISc C.E.D.T.
6. Harshvardhan, "Measurement Principles and Practices", Macmillan India Ltd-1993
7. Balaguruswamy E, "Reliability", Tata Mc Graw-Hill Pub.co. New Delhi, 1999.
8. Mourad Samiha & Zorian Yervant," Principles of Testing Electronic Systems", New York. John Wiley & Sons, 2000.
9. Lewis E E," Introduction to Reliability Engineering (2nd)", New York. John Wiley & Sons, 1996.
10. Anand M S," Electronic Instruments and Instrumentation Technology", New Delhi. Prentice Hall Of India, 2004.
11. Ott H W," Noise Reduction Techniques in Electronic System. ," (2) John Wiley & Sons New York, 1988.

Sub code	Subject Name	Teaching Scheme (Hrs)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ISE8041	Nuclear Instrumentation	4	2		4	-	1	5

Subject code	Subject Name	Examination Scheme							
		Theory(out of 100)					Term Work	Oral	Total
		Internal Assessment (out of 20)			End sem Exam	Exam duration (in Hrs)			
		Test 1	Test 2	Avg.					
ISE8041	Nuclear Instrumentation	20	20	20	80	03	25	25	150

Subject Code	**Subject Name**	**Credits**
ISE8041	**Nuclear Instrumentation**	**5**
Course Objectives	• To introduce the basic concept of radioactivity, properties of alpha,beta and gamma rays • To study various radiation detectors, detector classification • To study the electronics and counting systems • To study applications of nuclear instrumentation in medicines, Industry and in Agriculture.	
Course Outcomes	• The students get well versed with construction and working of various radiation detectors. • Students also get thorough knowledge of electronics and counting systems used in nuclear instrumentaion • Students get detailed information about applications of nuclear instrumentation in medicine, industry etc.	

Module	**Topics**	**Hrs.**
1	**Radioactivity** : General properties of Nucleus, Radioactivity, Nature of Nuclear Radiation's, Properties of Alpha, Beta and Gamma rays, Natural and artificial radio-activity. Radioactivity Laws, Half life period, radioactive series, Isotopes and Isobars, Various effects- photoelectric, Compton scattering and pair production, stopping power and range of charged nuclear particles.	8

2	**Radiation Detectors** : Techniques for radiation detection, Detectors for Alpha, beta and gamma rays, Detector classification,Gas filled detectors - volt ampere characteristics, Ionization chamber, Proportional counter, Geiger Muller counter, Designing features, Scintillation detectors, Photomultiplier tube, dark currents, pulse resolving power, efficiency of detection, Solid state detectors (Lithium ion drifted – Si-Li, Ge-Li, Diffused junction, surface barrier detectors)	14
3	**Electronics and Counting systems:** Pre-amp, shaping amplifiers, Discriminators, Scalars and count rate meters, Pulse shaping, peak stretchers, photon counting system block diagram, single channel analyzer SCA (pulse height analyzer - PHA), Coincidence detection	6
4	**Nuclear Spectroscopy systems:** Factors influencing resolution of gamma energy spectrum, Energy resolution in radiation detectors, Multichannel analyzers (MCA), Role of Nuclear ADC's – performance parameters.	6
5	**Radiation Monitors &Application in Medicines** : Radiation uptake studies – block diagram and design features. Gamma camera – design, block diagram, medical usage. Nuclear instrumentaion for health care, Radiation Personnel Health Monitors like neutron monitors, Gamma Monitors, Tritium monitors, Iodine monitors and PARA (paritculate acitivity radiation alarms).	8
6	**Applications in Industry** : Basic Nuclear Instrumentation system – block diagram, Personal monitors like Thermo Luminescence Detectors (TLD). Dosimeters, Tele-detectors. Nuclear Instrumentation for power reactor. Nuclear Insrumentation for Toxic fluid tank level measurement, weighing, thickeness gauges, Agriculture applications like food irradiation, Underground Piping Leak detection, water content measurement etc.	6

List of Laboratory Experiments:

1. To study preamplifiers for nuclear pulse processing.
2. To study pulse shaping circuit for nuclear pulse processing
3. To study discriminators for nuclear pulse processing
4. Study of GM Counter Pulses

Purpose: The purpose of this experiment is to familiarize oneself with typical output pulses of a GM counting system. The fact that the pulse height increases with increasing voltage through different regions (ionization, proportionality etc) and is roughly constant in the Geiger region including that pulse height is the same regardless of the energy or character of incident radiation

5. Study of the V-I characteristics of a GM Counting System.

Purpose: To study the variations of count rate with applied voltage and thereby determine the plateau region, operting voltage and slope of plateau.

6. To study the Gamma Ray Spectrometer based on SCA.

Purpose: The purpose is to understand the functioning and working of Spectrometer.

7. To obtain the spectrum of Gamma emitting isotope Cs 137 by using scintillator spectrometer.
8. To obtain the spectrum of Gamma emitting isotope Co 60 by using scintillator spectrometer.
9. To study the energy calibration of Spectrometer and analysis of the energy of unknown Gamma source.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 question need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Oral Examination:
Oral examination will be based on entire syllabus.

Term Work:

Term work shall consist of minimum three experiments (from the list given above) and ten assignments based on entire subject.
The distribution of marks for term work shall be as follows:

Laboratory work (Assignments)	: 10 Marks
Laboratory work (programs / journal)	: 10 Marks
Attendance (Theory and Practical)	: 5 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Text Books:

1. G.F. Knoll, “Radiation Detection & Measurement”, 2nd edition, John Wiley & Sons, 1998.
2. P.W. Nicholson, “Nuclear Electronics”, John Wiley, 1998.
3. S.S. Kapoor & V.S. Ramamurthy, “Nuclear Radiation Detectors”, Wiley Easter Limited, 1986.

Reference Books:

1. Gaur & Gupta, “Engineering Physics”, Danpat Rai & Sons, 2001.
2. Irvin Kaplan, “Nuclear Physics”, Narosa, 1987.
3. M.N. Avdhamule & P.G. Kshirsagar, “Engineering Physics”, S.Chand & Co., 2001.
4. R.M. Singru, “Introduction to Experimental Nuclear Physics”, Wiley Eastern Pvt. Ltd., 1974.
5. Hand Book of Nuclear Medical Instruments, Edited by B.R.Bairi, Balvinder Singh, N.C. Rathod, P.V. Narurkar, TMH Publishing New Delhi, 1974.

Sub code	Subject Name	Teaching Scheme (Hrs)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ISE8042	Power Plant Instrumentation	4	-	2	4	-	1	5

Sub code	Subject Name	Examination Scheme							
		Theory(out of 100)				Term Work	Pract. and oral	Oral	Total
		Internal Assessment (out of 20)			End sem Exam				
		Test 1	Test 2	Avg					
ISE8042	Power Plant Instrumentation	20	20	20	80	25	-	25	150

Subject Code	Subject Name	Credits
ISE8042	Power Plant Instrumentation	5

Course Objectives	• To create awareness of energy resources and its scenario in India. • To study the concept of power generation using various resources. • To study the role of Instrumentation in power plants. • To study and compare various power plants for optimal performance.
Course Outcomes	• The students get well versed with all power generation plants. • Students also get thorough knowledge of Instrumentation involve in power plants.

Module	Contents	Hours
1	**Introduction:** Energy sources, their availability, worldwide energy production, energy scenario of India. Introduction to Power generation, load curve, load factor. Classification of energy generation resources.	04
2	**Thermal Power Plant**- Method of power generation, layout and energy conversion process. Types of Turbines & their control. Types of Boilers and their control. Types of Generators and their control, Condensers. Types of Pumps and Fans, variable speed pumps and Fans, Material handling system, study of all loops-water, steam, fuel etc. Schematics of Gas turbine and Diesel power plant. Application of DCS in power plants.	14
3	**Hydroelectric Power Plant**- Site selection, Hydrology, Estimation electric power to be developed, classification of Hydropower plants. Types of Turbines for hydroelectric power plant, pumped storage plants, storage reservoir plants.	06

4	**Nuclear Power Plant –** Concept of energy generation from nuclear fission, control of chain reaction. Schematics of Nuclear power plant, types of reactors, reactor control, safety measures.	08
5	**Non-conventional Energy Resources** – **Wind Energy:** Power in wind, Conversion of wind power, Aerodynamics of wind turbine, types of wind turbine and their modes of operation, power control of wind turbines, Betz limit, Pitch & Yaw control, wind mill, wind pumps, wind farms, different generator protections, safety. **Solar Energy:** Solar resource, solar energy conversion systems. Solar PV technology: Block diagram of PV system, advantages and limitations. Solar thermal energy system: Principle, solar collector and its types, solar concentrator and its types, safety. Introduction to Modern Biomass, Bio-fuels, Geothermal energy, Tidal energy and Ocean thermal energy.	12
6	Comparison of different types of power plant: thermal power plant, hydro electric power plant, wind, solar, nuclear power plant on the basis of: Performance, efficiency, site selection, Economics-capital and running, safety. Introduction to Hybrid Power Generation concept.	04

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 question need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Oral Examination:

Oral examination will be based on industrial visit and entire subject.

Term Work:

Term work consists of minimum eight Tutorials/assignments based on entire subject and industrial visit report.

The distribution of marks for term work shall be as follows:

Laboratory work (Tutorials/Journal/Assignments) : 20 Marks

Attendance : 05 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on

minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Text Books:

1. "Power plant engineering", P.K.Nag, 3rd edition, 2010. McGraw Hill.
2. "Power Plant Instrumentation", K.Krishnaswamy, M. Ponni Bala, 2011, Prentice Hall India.
3. "A Textbook of Power Plant Engineering", by R.K.Rajput, 2010, Laxmi Publications.

Reference Books:

1. "Power Plant Engg.", Domkundwar
2. "Non-conventional energy resources", by B. H. Khan, McGraw Hill, New Delhi.
3. "Renewable energy Technology", Chetan Singh Solanki, Prentice Hall Publication.
4. "Solar Energy", by S. P. Sukhatme, Tata McGraw Hill, New Delhi.
5. "Nonconventional energy sources" G. D. Rai, Khanna Publication.
6. Solar Energy Technology vol I & II Dickinson & cheremision off.
7. Wind Energy Handbook**,** Tony Burton, David Sharpe, Nick Jenkins, Ervin Bossanyi (2001), John Wiley & Sons, ISBN: 0471489972,
8. Wind Energy Explained: Theory, Design and Application by James Manwell, J. F. Manwell, J. G. McGowan (2002), John Wiley and Sons Ltd, ISBN: 0471499722
9. Wind Turbine Operation in Electric Power Systems, Z. Lubosny (2003), Springer-Verlag New York, Inc ; ISBN: 354040340X.
10. David Lindsey, "Power Plant control and instrumentation – control of boilers HRSG", Institution of Engineering and Technology.
11. "Boiler Control Systems Engineering", by G.F. Gilman, 2005, ISA Publication.

Sub code	Subject Name	Teaching Scheme (Hrs)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ISE8043	Optimal Control Theory	4	-	2	4	-	1	5

Sub code	Subject Name	Examination Scheme							
		Theory(out of 100)				Term Work	Pract. and oral	Oral	Total
		Internal Assessment (out of 20)			End sem Exam				
		Test 1	Test 2	Avg.					
ISE8043	Elective-I : Optimal Control Theory	20	20	20	80	25	-	25	150

Subject Code	**Subject Name**	**Credits**
ISE8043	**Elective-I : Optimal Control Theory**	**5**
Course Objectives	• To make students understand the optimal control problems their types and how to solve them by calculus of variation and dynamic programming approaches. • To make student to understand the linear regulator and tracking systems, discrete time optimal control systems.	
Course Outcomes	The students will be able to • Identify various optimal control problems with performance measure with minimum time, minimum fuel, minimum energy, terminal cost and general problems. • Understand principle of calculus of variation, optimality, dynamic programming and their applications. • Make comparative study of problems based on calculus of variation, linear regulator, tracking and dynamic programming problems. • Understand applications of these methods for solving various optimal control problems.	

Module	**Topics**	**Hrs.**
1	**Introduction**: Formulation of optimal control problem, Performance measure, selecting a performance measure.	04
2	**Calculus of variation I** Fundamental concepts: functional, Linearity of functional, closeness, increment, variation, maxima and minima of functional, fundamental theorem of calculus of variation. Extremum of functional of single function: fixed and free end point problems, Extremum of functional of several independent function: fixed and free end point problems	10

3	**Calculus of variation II** Constrained extremum of functions: elimination method, Lagrange multiplier method Constrained extremum of functionals: point constraint, differential equation constraints, isoperimetric constraints The Variational approach to optimal control problems: necessary conditions for optimal control for different boundary conditions	10
4	**Linear Regulator and Tacking Systems:** Linear Quadratic Regulator(LQR): Finite time LQR and infinite time LQR Linear Quadratic Tracking Systems: Finite and infinite time Cases	06
5	**Discrete time Optimal control systems**: variational calculus for discrete time systems, Discrete time LQR and tracking systems	06
6	**Dynamic Programming**: Principle of optimality, application of principle of optimality to decision making, dynamic programming applied to routing problem, Hamilton-Jacobi-Bellman (HJB) equation, LQR system using HJB equation	12

Assignments:

Each student shall do at least **One** assignment on Module No. 1, **Two** assignments on Module Nos. 2, 3, 4 and 5 each, **Three** Assignments on Module No. 6. For all assignments, use MATLAB or Scilab or MathCAD simulation software.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 question need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Practical/Oral Examination:
Practical/Oral examination will be based on entire syllabus.

Term Work:
Term work shall consist of minimum eight experiments.
The distribution of marks for term work shall be as follows:

Laboratory work (Experiments)	: 10 Marks
Laboratory work (programs / journal)	: 10 Marks
Attendance (Theory and Practical)	: 05 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Assessment:
Internal Assessment consists of two tests out of which, one should be compulsory class test (on

minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Text Books:

1. D. S. Naidu, *Optimal Control System,* CRC Press LLC - 2003,
2. D. E. Kirk, *Optimal Control Theory - An Introduction*, Dover Publication, New York – 1998.

Reference Books:

1. B.D.O. Anderson and J.B. Moore. *Optimal Control, Linear Quadratic Methods*. Prentice-Hall Inc., Englewood Cliffs, NJ, 1989.
2. H. Kwakernaak and R. Sivan. *Linear Optimal Control Systems*. Wiley-Interscience, New York, 1972.
3. A. Sage. *Optimum systems control*. Prentice Hall, 2nd edition, 1977
4. F. L. Lewis and V. L. Syrmos. *Optimal Control theory*. Wiley Interscience, 2nd edition, 1995.
5. R. D. Robinett, D. G. Wilson, G. R. Eisler, and J. E. Hurtado. *Applied dynamic programming for optimization of dynamical systems*. Advances in Design and Control. SIAM, Philadelphia, 2005.
6. K. Ogata, Discrete Time Control System, Second Edition, PHI, Inc. 1995.

Sub code	Subject Name	Teaching Scheme (Hrs)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ISE8044	Nano Technology	3	2	--	3	--	1	4

Sub code	Subject Name	Examination Scheme							
		Theory(out of 100)				Term Work	Pract. and oral	Oral	Total
		Internal Assessment (out of 20)			End sem Exam				
		Test 1	Test 2	Avg.					
ISE8044	Nano Technology	20	20	20	80	25	-	25	150

Subject Code	**Subject Name**	**Credits**
ISE8044	Nano Technology	**5**
Course Objectives	• To explain students to basic concepts of nanodevices and various sensors. • To provide knowledge about the applications of nanotechnology	
Course Outcomes	The students will be able to • Understand the working of MEMS and NEMS • Understand the applications of nanosensors and detectors	

Module	**Topics**	**Hrs.**
1	**SEMICONDUCTOR NANODEVICES:-** Single Electron devices- Nano scale MOSFET – Resonant Tunneling Transistor – Single Electron Transistors - Single Electron Dynamics - Nanorobotics and Nanomanipulation - Mechanical Molecular Nanodevices - Nanocomputers: Theoretical Models - Optical Fibers for Nanodevices - Photochemical Molecular Devices – DNA Based Nanodevices – Gas based Nanodevices - Micro and Nanomechanics. Schottky devices - Quantum Structures and Devices - Quantum layers, wells, dots and wires - Mesoscopic Devices - Carbon Nanotube based logic gates, optical devices - Connection with quantum dots, quantum wires, and quantum wells- Single Molecule electronic devices – photonic band gap systems: applications and devices.	10
2	**MEMS AND NEMS:-** Development of micro electronics - Region of Nanostructures - methods and limits on microminiaturization in semiconductors- micro electro mechanical system. Silicon micromachining- semiconductors and insulator Microsystems fabrication techniques - Silicon MEMS fabrication technology - Single crystal reactive etching and metallization process.	20

	Non-silicon MEMS and fabrication techniques - SIC MEMS - Biomedical-MEMS techniques - Integration of microsystems with electronics – RF MEMS – Applications. Polymers in Microsystems - Packaging of MEMS devices by anodic/fusion bonding - Pressure sensors and packaging - MEMS performance and evaluation. Nano electro mechanical systems - fabrication and process techniques - lntegration of nanosystems and devices - applications and future challenges.	
3	**NANOSENSORS, DETECTORS AND THEIR APPLICATIONS:-** **SENSOR CHARACTERISTICS AND PHYSICAL EFFECTS:** Active and Passive sensors – Static characteristic - Accuracy, offset and linearity – Dynamic characteristics - First and second order sensors – Physical effects involved in signal transduction- Photoelectric effect – Photo dielectric effect –Photoluminescence effect– Electroluminescence effect – chemiluminescence effect – Doppler effect – Barkhausen effect – Hal effect Ettinshausen effect – Thermoelectric effect – Peizoresistive effect – Piezoelectric effect – Pyroelectric effect –Magneto-mechanical effect (magnetostriction) – Magneto resistive effect.	08
4	**Gas sensor materials:** Criteria for the choice of materials, Experimental aspects – materials, properties, measurement of gas sensing property, sensitivity; Discussion of sensors for various gases, Gas sensors based on semiconductor devices.	06
5	**Biosensors:** Principles- DNA based biosensors – Protein based biosensors – materials for biosensor applications- fabrication of biosensors - future potential.	04

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 question need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Practical/Oral Examination:
Practical/Oral examination will be based on entire syllabus.

Term Work:
Term work shall consist of minimum eight experiments/assignments.
The distribution of marks for term work shall be as follows:
Laboratory work (Experiments) : 10 Marks
Laboratory work (programs / journal) : 10 Marks
Attendance (Theory and Practical) : 05 Marks
The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Assessment:

Internal Assessment consists of two tests out of which, one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

REFERENCES:-

1. Charles P.Poole Jr and. Frank J.Owens, "Introduction to Nanotechnology", Wiley Interscience, 2003.
2. G. Cao, "Nanostructures and Nanomaterials: Synthesis, Properties and Applications", Imperial College Press, 2004.
3. C.M. Niemeyer and C.A. Mirkin, "Nanobiotechnology, Concepts, Applications and perspectives", WILEY-VCH, 2004.
4. G.M.Chow and K.E.Gonsalves, "Nanotechnology - Molecularly Designed Materials", American chemical society Symposium series 622, 1996.
5. K.P.Jain, "Physics of semiconductor Nanostructures", Narosa Publishers, 1997.
6. W.R.Fahrner, "Nanotechnology and Nanoelectronics: Materials, Devices, Measurement Techniques", Springer, 2005.
7. K.Goser, P.Glosekotter & J.Dienstuhl, "Nanoelectronic and Nanosystems – From Transistors to Molecular Quantum Devices" Springer, 2004.
8. S. E. Lyshevski, "MEMS and NEMS: Systems, Devices and Structures", CRC Press, 2002.
9. Gregory Timp, "Nanotechnology", Springer, 1999.
10. Vijay K Varadan, K J Vinoy, S Gopalakrishnan, "Smart Material Systems and MEMS: Design and Development", John Wiley &Sons, 2006.

Sub code	Subject Name	Teaching Scheme (Hrs)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ISE8045	**Fiber Optic Instrumentation**	4	2	-	4	1	-	5

Sub code	Subject Name	Examination Scheme							
		Theory(out of 100)				Term Work	Pract. and oral	Oral	Total
		Internal Assessment (out of 20)			End sem Exam				
		Test 1	Test 2	Avg.					
ISE8045	**Fiber Optic Instrumentation**	20	20	20	80	25	--	25	150

Subject Code	**Subject Name**	**Credits**
ISE8045	**Fiber Optic Instrumentation**	**5**
Course Objectives	• To expose the students to the basic concepts of optical fibres and their properties. • To provide adequate knowledge about the Industrial applications of optical fibres.	
Course Outcomes	The students will be able to: • Identify various sensors, Fiber optic and its specifications. • Understand principle of working of Fiber Optic used to measure Temperature, Displacement, Level, and various miscellaneous other sensors • Understand applications of Fiber Optics in industry.	

Module	**Topics**	**Hours**
1	**Optical Fiber and Their properties:** Ray theory, wave guiding principles, Theory of optical wave propagation, Types and classification of optical fibers, optical fiber mode, single mode fiber, special fiber, fiber materials, fiber fabrication, transmission characteristics of fiber, absorption losses, scattering losses, dispersion, polarisation, non-linear phenomena	08
2	**Optical Sources and Detectors, Power Launching and Coupling:** Laser theory, Laser diodes, LED, PN diode, Pin diode, avalanche diode, solid, liquid, gas and semiconductor laser their characteristics modulation circuits, optical detection principles, quantum efficiency and detector noise, Source to fiber power launching, fiber alignment and fiber to fiber joints, splices, connectors, coupling losses, lensing schemes for coupling improvement, LED coupling to single mode fiber.	12

3	**Optical Fiber Measurements:** Measurement of attenuation, dispersion, refractive index profile of fiber and cut off wavelength, numerical aperture, OTDR, Measurement of flow, pressure, Temperature, displacement, acceleration and fluid level vibration measurement.	06
4	**Fiber Optic Sensing Principles and Techniques:** Classification and principle of fiber optic sensors, fiber grating and fiber Bragg grating technology and distributed optical fiber sensing.	06
5	**Optical Amplification and Integrated Optics:** Beam splitter, directional coupler, opto isolators, multi mode interference coupler(MMIC) optical modulators, fiber modulator optical amplifiers, optical switches, frequency translators, optoelectronic integration.	08
6	**Holography and Laser instruments in medical application and Remote Sensing:** Basic principle, methods, Holographic interferometry. Application of laser in medical application, laser in industrial application. Components of Remote sensing, Active and passive Remote Sensing-platforms, Electro-magnetic radiation(EMR),EMR spectrum	**08**

List of Experiments:

1. Study of Fiber optic communication set-up.
2. To measure numerical aperture of an optical fiber.
3. To study characteristic curves of optical sources and detectors.
4. To plot spectral response characteristics of photodiode
5. Displacement measurement by fiber optic sensor.
6. Characteristics of opto- coupler
7. To study attenuation losses in optical fiber.
8. To study dispersion losses in optical fiber.
9. To study different splicing techniques.
10. Design of an optical fiber sensor.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 question need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Oral Examination:
Oral examination will be based on entire syllabus.

Term Work:
Term work shall consist of minimum eight experiments.
The distribution of marks for term work shall be as follows:

Laboratory work (Experiments)	: 10 Marks
Laboratory work (programs / journal)	: 10 Marks
Attendance (Theory and Practical)	: 05 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Assessment:

Internal Assessment consists of two tests out of which, one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Text Books:

1. "Fiber optics – communication", Gerd Keiser.
2. "Integrated circuits and semiconductor devices theory and application" Deboo Burrous, McGraw Hill Second Edition.

Recommended Books:

1. "Opto Electronics – An Introduction", J.Wilson J.F.B.Hawkes, Prentice Hall of India New Delhi. 1996.
2. "Optical fiber communications principles and practice", J.M. senior Prentice Hall of India , Second Edition 1996
3. "Fiber optics - communication and other application", H. Zanger and Zanger McGraw Pub
4. "Optical fiber systems, Tecnology, Design & Application", Kao C.K.,McGraw Hill.
5. "Introduction to optical fibers", Cherin, McGraw Hill.
6. "Text book on optical fiber Communication & it's application" S.C.Gupta (PHI)
7. "Basics of Remote Sensing & GIS", By: Dr. S. Kumar (Laxmi publications)