University of Mumbai

Syllabus Structure (R-2007)

At

B.E. (Instrumentation Engineering)

Semester-VII

S. No.	Subject	Scheme of Instructions Periods (60 min. each) per Week		Scheme of Evaluation					
		Theory	Practical	Paper		TW	Practical & Oral	Oral	Total Marks
				Hours	Marks				
1.	Industrial Process Control	04	02	3	100	25	--	25	150
2.	Biomedical Instrumentation.	04	02	3	100	25	--	25	150
3.	Advanced Control Systems	04	02	3	100	25	25	--	150
4.	Process Automation	04	02	3	100	25	--	25	150
5.	Elective-I	04	02	3	100	25	--	25	150
6.	Project-I	--	02	--	--	25	--	25	50
	Total	20	12	---	500	150	25	125	800

Semester-VIII

S. No.	Subject	Scheme of Instructions Periods (60 min. each) per Week		Scheme of Evaluation					
		Theory	Practical	Paper		TW	Practical & Oral	Oral	Total Marks
				Hours	Marks				
1.	Batch Process Automation	04	02	3	100	25	25	--	150
2.	Instrumentation Project Documentation & Execution	04	02	3	100	25	--	25	150
3.	Instrument & System Design	04	02	3	100	25	--	25	150
4.	Elective-II	04	02	3	100	25	--	25	150
5.	Project-II.	--	08	--	--	50	--	50	100
	Total	16	16	---	400	150	25	125	700

Elective Subjects

Semester-VII	**Semester-VIII**
Elective-I	**Elective-II**
Advanced Embedded Systems	Power Plant Instrumentation
Fiber Optic Instrumentation	Digital Control System
Process Modeling and Optimization	Optimal & Robust Control Systems
Image Processing	Nuclear Instrumentation
Expert Systems	Automation in Energy and Infrastructure

University of Mumbai			
Class: B.E.	**Branch:** Instrumentation Engineering	**Semester:** VII	
Subject: Industrial Process Control (Abbreviated as IPC)			
Periods per Week (60 min.each)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Oral	---	25
	Term Work	---	25
	Total	---	150

Module	Contents	Hours
01	**Introduction:** Review of all strategies for process control, SISO, MIMO, ISA symbols.	02
02	**Control System for Heat transfer unit operations:** Heat exchangers: classification as per fluid flow arrangement and construction, feedback, feed-forward, bypass control. Furnace control: Start- up heaters, fired re-boilers, process and safety controls. Evaporator control: Types of Evaporator and multiple effect evaporator, control systems for Evaporator including selective control, steady state model for Evaporator. Boiler controls: Temperature and Pressure control of steam, Combustion control, Drum level control, Furnace draft control, safety interlocks and Burner Management System.	13
03	**Control System for Heat and mass transfer unit operations** Distillation column: Basic principle, Batch and continuous distillation, accessories, Distillation column control strategies. Crystallizers: Super-saturation methods, Process of crystallization, types of crystallizer, control of evaporating crystallizer, cooling crystallizers, vacuum crystallizers. Dryer control: Process of drying, types of dryer- Tray, fluidized bed, rotary, and spray, and their control strategies. Reactor control: Reactor characteristics, runaway reaction, various schemes of temperature control of reactors.	12
04	**Control system for compressor:** Classification, Phenomenon of Surge, Methods of capacity control for compressors.	03

05	**Process control for Industries:** **Continuous Process Industries:** Refinery Industry**:** Process flow diagram, separation, treatment-Hydro-desulphurization unit, conversion methods- Fluid Catalytic Cracking, blending. Iron and steel Industry: Process flow diagram, its Instrumentation. **Batch Process Industries:** Overview of food processing & pharmaceutical industries and the same to be studied with reference to following aspects 1.Charging of Raw Materials 2.Heating/cooling using different utilities 3.Milti product recipe management 4.Reports	14
06	**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 consist of total 7 questions carrying 20 marks each.
2. Only 5 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 six assignments/experiments, written test and report of Industrial Visit. Industrial visit consists of

I) Process Flow Diagram From any of the industries listed above.

II) Process and Control Simulation on Distillation Column, Heat Exchanger etc

The distribution of the term work shall be as follows,

Laboratory work (Experiments and Journal) :15 marks

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.

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.

University of Mumbai			
Class: B.E.	**Branch:** Instrumentation Engineering	**Semester:** VII	
Subject: Biomedical Instrumentation (Abbreviated as BMI)			
Periods per Week (60 min. each)	Lecture	04	
	Practical	02	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory	03	100
	Oral	---	25
	Term Work	---	25
	Total	---	150

Module	Contents	Hours
1	**Human Body System Overview:** Structure of cell, respiratory system, nervous system, nerve muscle physiology, Cardiovascular system.	4
2	**Cell Activity and Origin of Bio-potential:** Origin of Bio-potential, Electrical activity of cell, Action Potential and its propagation, Origin of EMG, EEG, ECG, ERG and EOG.	4
3	**Measurement of Biochemical and Bioelectric potential:** Biochemical transducers – pH, PO_2, PCO_2, Bio-potential electrodes- electrode theory, electrode – electrolyte interface, Types of electrodes, bio-potential amplifier and its characteristics.	4
4	**Cardiovascular Measurements:** Blood Flow, Blood Pressure, Blood volume, Cardiac Output and Heart sound measurement. Oxymeter.	8
5	**Diagnostic Instruments:** EMG, EEG, ECG. **Therapeutic Instruments:** Pacemaker, Defibrillator and Incubator. **Life support systems:** Heart Lung Machine, haemodialysers, and ventilators.	12
6	**Imaging Techniques*:** X-Ray Generation and X-Ray Machine, CT – Scanning, Ultrasound Imaging, Magnetic Resonance Imaging, Nuclear Medicine (Gamma Camera) and their applications.	12
7	**Significance of Electrical Safety:** Physiological effects of electrical current, Shock Hazards from electrical equipments	4

	and methods of accident prevention.	

*- **A Hospital Visit is recommended for imaging Instruments.**

Theory Examination:

1. Question paper will consist of total 7 questions carrying 20 marks each**.**
2. Only 5 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.

Oral Examination:

Oral examination will be based on entire subject.

Term Work:

Term work consists of experiment no. 1 and minimum 4 experiments from experiment no. 2 to 9, two assignments, report of hospital visit and a written test. The distribution of the term work shall be as follows-

Laboratory work (Journal) :15 marks
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

List of Laboratory Experiments:

1. Demonstration of instruments like EMG, EEG, ECG, PPG, PCG etc.
2. Study of electrodes
3. To design and implement ECG signal conditioning along with lead fail detector, filters and adjustable threshold detector.
4. To Design and implement asynchronous Pacemaker CKT.
5. Microprocessor based heart rate indicator.
6. ECG simulation on PC.
7. ECG simulation using microcontroller
8. To design and implement EMG quantification Circuit.
9. To design Defibrillator Circuit.

Text Books:

1) Leslie Cromwell, "Biomedical Instrumentation and Measurements", 2nd Edition, Pearson Education, 1980.
2) Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment

Technology", PHI/Pearson Education, 4th edition, 2001.

Reference Books:

1) Richard Aston, "Principles of Biomedical Instrumentation and Instruments", 1991.
2) John G. Webster, "Medical Instrumentation", John Wiley and Sons, 1999.
3) R. S. Khandpur, "Biomedical Instrumentation", TMH, 1994

University of Mumbai			
Class: B. E.	**Branch:** Instrumentation Engineering	**Semester:** VII	
Subject: Advanced Control Systems (Abbreviated as ACS)			
Periods per Week (each 60 min)	Lecture	4	
	Practical	2	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory	3	100
	Practical & Oral	--	25
	Term Work	--	25
	Total	--	150

Module	Contents	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
1	**Nonlinear Control Systems and Analysis** Definition of nonlinear systems**,** Difference between linear and nonlinear systems, Characteristics of nonlinear systems**,** Common physical nonlinearities. **Analysis and Design of Nonlinear Control System:** Phase Plane Analysis, Phase plane method - basic concept, trajectories, phase portrait, singular points and their classification, limit cycle and behavior of limit cycle, Phase plane analysis of nonlinear systems, Construction of phase trajectories using delta method. **Describing Function Analysis (DF):** Derivation of general DF, DF for different nonlinearities, and Stability analysis of nonlinear system: Prediction of stability of nonlinear systems using DF method, Relay, Dead-zone, Backlash, and Saturation. **Linearization Techniques:** Linearization by small signal analysis (Taylor series expansion), linearization by nonlinear feedback, linearization by inverse nonlinearity, and Conditional stability analysis using root locus.	20
2	**Liyapunov Stability Analysis** **Norms for Signals and Systems:** 1, 2 & inf norms for signals and systems **Liyapunov Stability Analysis:** Stability of equilibrium state, asymptotic stability, graphical representation, Lyapunov stability theorems, stability analysis of linear systems, nonlinear systems, construction of Lyapunov functions using	12

	Krasovskii method, variable gradient method	
3	**Introduction to Adaptive Control System** Definition of adaptive control system, functions of adaptive control, gain scheduling, model reference, series and parallel schemes and their industrial applications.	06
4	**Introduction to Sliding mode Control** Introduction, concept of variable structure control (VSC), ideal sliding motion and chattering, switching function, reachability condition, properties of sliding motion	09

Theory Examination:

1. Question paper will consist of total 7 questions of 20 marks each.
2. Only 5 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.
6. No question should be asked from the pre-requisite module

Practical and Oral Examination:

Practical and oral examination will be based on one experiment performed from the list of experiments given in the syllabus and the oral will be based on entire subject.

Term work:

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

Laboratory work (Experiments and Journal) :15 marks
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.

List of Laboratory Experiments:

1) Nonlinear Control System and Analysis
   a) Construct the trajectory for system represented by second order differential equation and for any initial condition by using Iso-cline and Delta Methods
   b) Draw the trajectory for the system with nonlinear element – relay, saturation, etc. for any initial condition and step input by using Iso-Cline and Delta Methods.
   c) Study the 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, relay with Hysteresis etc.
   e) Investigate the stability of system with nonlinearities – relay, saturation, dead-zone, hysteresis and existence of limit cycle using DF technique.
2) Liyapunov Stability Analysis
   a) Verify Sylvester theorem for the definiteness of the Liyapunov Function.

b) Determine the stability of the system and construct the Liyapunov function for – Linear Time Invariant system.
c) By using Krasovskii method determine the stability of the system and construct the Liyapunov function.
d) By using Variable Gradient method determine the stability of nonlinear system.

3) Adaptive control
Study the different schemes of adaptive control and their applications.

4) Sliding Mode Control.
a) Study the sliding modes of the system with at least two examples.
b) Study the properties of sliding motion with examples.

Books Recommended:

Text Books:

1. M. Gopal, "Modern Control System Theory", Wiley Eastern Ltd., New Delhi.
2. K. Ogata, "Modern Control Engineering", 3 ed. Prentice Hall of India (P) Ltd., New Delhi.
3. Dr. K.P. Mohandas, "Modern Control Engineering", revised edition, Sanguine Publishers, Bangalore, 2006.

Reference Books:

1. Gene F. Franklin, J David Powell, Abbas Emami-Naeini, "Feedback Control of Dynamic Systems", 5ed Pearson Educations.
2. Shankar Sastry, Marc Bodson, "Adaptive Control", Prentice Hall of India (P) Ltd., 1993.
3. John Doyle, Bruce Francis, Allen Tannenbaum, "Feedback Control Theory".
4. Pierre R. Belanger, "Control Engineering" Saunders college Publishing.
5. Norman Nise, "Control system Engineering, 4 ed.Wiley International Edition".
6. Christopher Edwards, Sarah K. Spurgeon, "Sliding Mode control: Theory and Application", 1998.
7. Karl J. Astrom, B. Wittenmark, "Adaptive Control", 2nd Edition, Pearson Education Asia, First Indian Reprint, 2001
8. Stanislaw H. Zak, "Systems and Control", Indian Edition, Oxford University Press, 2003.

University of Mumbai			
Class: B.E.	**Branch:** Instrumentation Engineering	**Semester:** VII	
Subject: Process Automation(Abbreviated as PA)			
Periods per Week (60 min. each)	Lecture	04	
	Practical	02	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory	03	100
	Oral	---	25
	Term Work	---	25
	Total	---	150

Module	Contents	Hours
01	**Automation Fundamentals** 1.1 Automation and its importance, automation applications, expectations of automation. 1.2 Types of plant and control – categories in industry, open loop and close loop control functions, continuous processes, discrete processes, and mixed processes. 1.3 Automation hierarchy – large control system hierarchy, data quantity & quality and hierarchical control. 1.4 Control system architecture – evolution and current trends, comparison of different architectures.	04
02	**Programmable Logic Controller** **Hardware** 2.1 Evolution of PLC, Definition, functions of PLC, Advantages, Architecture, working of PLC, Scan time, Types & Specifications. 2.2 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, 2.3 Memory & addressing- memory organization (system memory and application memory), I/O addressing, hardware to software interface. **Software** 2.4 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	12

	instructions, PID Control using PLC. **Case study:** 2.5 PLC selection and configuration for any one process applications**.**	
03	**Distributed Control system** : 3.1 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. 3.2 Introduction to Hierarchical Control and memory: Task listing, Higher & Lower Computer level tasks. 3.3 Supervisory computer tasks and DCS configuration – Supervisory Computer functions, Control techniques, Supervisory Control Algorithm, DCS & Supervisory Computer displays, advanced control Strategies, Computer interface with DCS. 3.4 DCS – system integration with PLCs and computer: Man machine interface- sequencing, supervisory control, and integration with PLC, personal computers and direct I/O, serial linkages, network linkages, links between networks.	12
04	**Database & Alarm Management** 4.1 Database management, Historical Data use in logs, reports and trend displays, System Status Display, Process Reports, different types of logs and reports. 4.2 Philosophies of Alarm Management, Alarm reporting, types of alarms generated and acceptance of alarms.	04
05	**Supervisory Control and Data Acquisition (SCADA)** 5.1 SCADA introduction, brief history of SCADA, elements of SCADA. 5.2 Features of SCADA , MTU- functions of MTU, RTU- Functions of RTU, Protocol Detail 5.3 SCADA as a real time system 5.4 Communications in SCADA- types & methods used, components, Protocol structure and Mediums used for communications 5.5 SCADA Development for any one typical application	08
06	OPC, Historian, MES, Integration with enterprise system.	04
07	**Safety Instrumented System (SIS)** **7.1** Need for safety instrumentation- risk and risk reduction methods, hazards analysis. Process control systems and SIS. 7.2 Safety Integrity Levels (SIL) and availability. Introduction	04

	to the international functional safety standard IEC61508.	

Theory Examination:

1. Question paper will consist of total 7 questions carrying 20 marks each.
2. Only 5 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

Oral Examination:

Oral examination will be based on entire subject.

Term Work:

Term work consists of minimum 4 assignments, 4 PLC programs for process control applications and a written test. The distribution of the term work shall be as follows,

Laboratory work (Journal) :15 marks
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

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", Third 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;

University of Mumbai			
CLASS: B. E.	**Branch:** Instrumentation Engineering	**Semester** - VII	
Elective-I : Advanced Embedded Systems (abbreviated as AES)			
Periods per week (each of 60 minutes)	**Lectures**	04	
	Practical	02	
	Tutorial	---	
		Hours	**Marks**
Evaluation System	Theory	03	100
	Practical & Oral	--	--
	Oral	--	25
	Term Work	--	25
	Total	--	150

Module	Contents	Hours
1.	**ARM Processor** Introduction to ARM7 & ARM9 Architecture ARM 7: ARM-THUMB mode, programming model, instruction set, and programming. 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 • Timer programming- Timer / Capture mode • Serial port programming for PC communication • PWM Signal generation • Idle and Power down mode • Interrupt handling • Frequency measurement Interfacing with ARM based chip like LPC2129 • 7 segment display, Character and Graphics LCD • Keyboard (1 to 20) keys SPI Interface based External DAC like MCP4921/22 • SPI Interface based External ADC like MCP3202/4/8	8

	• IIC based Memory interface 24CXX • Relay/SSR LED interfacing with and without opto-isolation.	
2.	System Design Instrumentation System design with ARM processor (Instrumentation Hardware design to be at Block level only) - Data Acquisition System with o MMI (Character/Graphics LCD with Keypad of 20 keys) o 4 channel Analog Inputs o Selectable Sampling rate o PC based Data Logging using Serial port. - PID Controller o 7 segment, 4- digit Dual Display with first one for Current parameter value and Second for Set parameter value. o 4 Keys for PID Setting input o One SSR/Relay output Alarm using Buzzer, which will be reset on key press.	18
3.	**Embedded/ Real Time Operating system Concepts**: Definition, Embedded systems overview, System components, Multiple process & Tasks, Task states & TCB , Task scheduler models, Interrupt service routines, Interrupt Handling and Latency, Inter Process Communication: Semaphores, Shared Data, Mutex, IPC, Signals, Mail boxes, Message queue, Socket & events, pipes, and signals. OS Services: Process management, Memory management, timer function, Event Functions, Device and File I/O subsystems, RTOS Interrupt handling, Priority inversion problem. Basic Design using RTOS. Overview of Real time operating system: RTLinux, VxWorks, MicroC /OS.	8
4.	Real Time operating system Application development outlines using typical RTOS - RTOS Initialization and availing its services for application work. Functions provided for : System Level, Task Service and Time management, Time Delay, Memory management, Semaphore, Mailbox, and Queue Management	9

5.	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.	4

Theory Examination:

1. Question paper will have total 7 questions of 20 marks each.
2. Only 5 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 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.

Distribution of the term work shall be as follows,
Laboratory work (Experiments, seminar & case study) :15 marks
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.

Text 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.

Websites:

1. www.nxp.com - LPC21XX Datasheets, IIC Datasheets
2. www.atmel.com - 24CXX Dataesheets, , IIC Datasheets

3. www.microchip.com - MCP 32XX and MCP 49XX Datasheets
4. www.xilinx.com - CPLD XC9500, XC4000 Datasheets

University of Mumbai			
Class: B.E.	**Branch:** Instrumentation Engineering	**Semester-**VII	
Elective-I : Fiber Optic Instrumentation **(Abbreviated as FOI)**			
Periods per Week (each 60 min)	Lecture	04	
	Practical	02	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory	3	100
	Oral	--	25
	Term Work	--	25
	Total	--	150

Module	Contents	Hours
1	Introduction to Optical Fiber Communication : Elements of an Optical Fiber Transmission link., Optical Fiber modes, and configurations, Single mode fibers, Fiber materials, Fiber fabrication, Fiber Optics – basic characteristics, sensors – basic principle and operational details. Holography: principles, holographic recording and readout devices, its application. Optical signal processing – Fourier optics, optical applications	08
2	Optoelectronics: Light sources- LED, Laser Diodes. Optical detectors, their characterization. Light source- linearity, Reliability considerations**.** Opto-isolators: their characteristics, advantages and limitations. Lasers-theory, types, characteristics.	06
3	POWER LAUNCHING & COUPLING: Sources to Fiber power launching, Lensing schemes for coupling improvement, Fiber to fiber joints, LED coupling to single mode fibers, Fiber splicing, Optical Fiber connectors.	06
4	PHOTODETECTOR: Physical principles of photo diodes, Photo detector noise, Detector response time, Avalanche multiplication noise, Temperature effect on avalanche gain.	04
5	WDM Concepts & Components: Operational principle of WDM, Passive components, Tunable sources, Tunable filters.	04
6	OPTICAL NETWORKS : Basic networks, SONET / SDH, Broadcast and select WDM networks, Wave length routed networks, Non linear effects on network performance, Performance of WDM +EDFA systems, Optical CDMA, Ultra high capacity networks.	04
7	MEASUREMENTS APPLICATIONS : Measurement Standards & Test Procedure Test equipments, Attenuation	08

	Measurement, Dispersion measurement, Distance measurement, Flow measurement, Level measurement, Pressure and Vibration measurement, Endoscopy, Holography.	
8	REMOTE SENSING : Parameters of a Sensors, Definition : Components of Remote sensing – Energy, sensor, interacting Body, Active & passive Remote sensing – platforms—Aerial & space platforms--Balloons, Helicopter, Aircraft & satellites – Synoptivity and Receptivity--Electro Magnetic Radiation (EMR) - EMR spectrum--visible, Infra Red (IR), Near IR, Middle IR, Thermal IR & Microwave-Black body radiation-plank's Law-Stefan-Boltzman Law.	08

Theory Examination:

1. Question paper will have total 7 questions of 20 marks each.
2. Only 5 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
6. No question should be asked from the pre-requisite module

Oral Examination:

Oral examination will be based on entire subject.

Term work:

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

Laboratory work (Experiments and Journal) :15 marks
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.

List of Laboratory Experiments:

1) To plot spectral response characteristics of photodiode
2) To plot spectral response characteristics of photo transistor
3) To plot intensity response of photo diode
4) To plot intensity response of phototransistor.
5) Study of Fiber optic communication set-up.
6) Numerical aperture measurement of optical fiber.
7) Displacement measurement by fiber optic sensor.
8) Data communication by optical fiber.
9) Characteristics of opto- coupler

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
4. "Fiber optics - communication and other application", H. Zanger and Zanger McGraw Pub
5. "Optical fiber systems, Tecnology, Design & Application", Kao C.K.,McGraw Hill.
7. "Introduction to optical fibers", Cherin, McGraw Hill.
8. "Text book on optical fiber Communication & it's application" S.C.Gupta (PHI)
9. "Basics of Remote Sensing & GIS", By: Dr. S. Kumar (Laxmi publications)

University of Mumbai			
Class: B.E.	**Branch**: Instrumentation Engineering	**Semester** - VII	
Elective-I : Process Modeling and Optimization (PMO)			
Periods per week (each of 60 minutes)	Lectures	04	
	Practical	02	
	Tutorial	---------	
		Hours	**Marks**
Evaluation System	Theory	03	100
	Oral	------	25
	Term Work	------	25
		Total	150

Module No.	Contents	Hours
1.	**Mathematical Modeling** 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)	08
2.	**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.	05
3.	**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
4.	**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, Big-M method, Duality in LPP	12
5.	**Numerical Methods for Unconstrained Optimum Design:** General algorithm for constrained and unconstrained minimization methods, rate of convergence, unimodal and multimodal function ,reduction of a single variable, one dimensional minimization methods- Equal Interval method,	13

	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), Quasi-Newton method: Davidon-Fletcher-Powell, Broyden–Fletcher-Goldfarb-Shanno.	

Theory Examination:

1. Question paper will consist of total 7 questions of 20 marks each.
2. Only 5 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
6. No question should be asked from the pre-requisite module

Oral Examination:

Oral examination will be based on entire subject.

Term work:

Term work consists of minimum ten assignments and a written test. The distribution of the term work shall be as follows,

Laboratory work (Assignments and Journal) :15 marks
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.

Assignments: Each student shall do at least **One** assignment on Module No. 1, **Two** assignments on Module No. 2, **Three** Assignments on Module No. 3 and **Four** assignments on Module No. 4 and 5 each. For assignments on Module No. 5 use Optimization Toolbox of MATLAB.

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.

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.

University of Mumbai			
CLASS: B. E.	**Branch:** Instrumentation Engineering	**Semester** - VII	
Elective-I: Image Processing (Abbreviated as IP)			
Periods per week (each of 60 minutes)	Lectures	04	
	Practical	02	
	Tutorial	---	
		Hours	**Marks**
Evaluation System	Theory	03	100
	Oral	--	25
	Term Work	--	25
	Total	--	150

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.	04
2.	**Digital Image Fundamentals**: Elements of visible perception, image model, sampling and quantization, relationships between pixels, imaging geometry.	04
3.	**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)	08
4.	**Image Enhancements**: Point operations, histogram modeling, spatial filtering-smoothing, sharpening, low pass, high pass, homomorphic filtering.	06
5.	**2-D systems and mathematical preliminaries**: Introduction and definitions, matrix theory, random signals, spectral density function, results from estimation and information theory.	08
6.	**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.	08
7.	**Image Segmentation:** Detection of discontinuities, age linking and boundary detection, thresholding region oriented segmentation, use of motion in segmentation.	05
8.	**Image Data Compression:** Introduction, pixel coding, predictive techniques (PCM, DPCM, etc), transform coding theory of images, hybrid coding and vector DPCM.	05

Theory Examination:

1. Question paper will consist of total 7 questions of 20 marks each.

2. Only 5 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 syllabus.

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

Laboratory work (Experiments and Journal) :15 marks
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.

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.

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.

University of Mumbai			
Class: B.E.	**Branch:** Instrumentation	**Semester:** VII	
Elective-I: Expert Systems (Abbreviated as ES)			
Periods per Week (60 min. each)	Lecture	04	
	Practical	02	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory	03	100
	Oral	---	25
	Term Work	---	25
	Total	---	150

Module	Contents	Hours
1	**Introduction to Expert System** What are Expert Systems, Features of Expert System, features of good Expert System, Role of human in Expert System, Expert System organization, Difference between expert system and conventional program, Basic activities of expert system and the areas in which they solve problems, Prospector systems-features, working	3
2	**Expert System Tools** Knowledge representation in expert systems-using rules semantic nets, frames, Types of tools available for expert system building and how they are used, Stages in the development of expert system tools, Examples of knowledge engineering	7
3	**Building an Expert Systems** Necessary requirements for expert systems development, Justification for expert system development, Task in building expert systems, Stages of expert system development, Choosing a tool for building expert system, Acquiring knowledge from the experts, Examples of the expert system-building process, Examples of expert system used in different areas	4
4	**Difficulties in developing an expert system** Common pitfalls in-planning an expert system, Scaling with the domain expert during development process.	5
5	**Neural Network Introduction** Biological neural networks-neuron physiology, eye's neural network, Artificial neuron models, Neural net architecture (Topologies), Learning in ANN, Characteristics of ANN	7

6	**Supervised Learning** Single layer networks-perceptrons, Linear separability, Perceptron training algorithm, Modifications multi-layer network-multi-layer discrimination, back propagation algorithm, Classification using back propagation algorithm, Application of back propagation algorithm, Adaptive multiplier networks-algorithm, boosting, prediction network, radial basis functions	**6**
7	**Unsupervised Learning** Winner-take all networks, Learning vector quantiser, Co-inter propagation networks, Adaptive response theory	**5**
8	**Associative Networks** Non-interactive procedures for association, Hopfield networks, Optimization using Hopfield networks, Brain state in a box network, Boltzmann machines, Hetero associators	**5**
9	**Fuzzy Logic** Propositional logic, Membership functions, Fuzzy logic, Fuzzy rule generation, De-fuzzification, Time dependent fuzzy logic, Temporal fuzzy logics, Case study-to use fuzzy logic for processes control problem	**6**

Theory Examination:

1. Question paper will consist of total 7 questions carrying 20 marks each**.**
2. Only 5 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.

Oral Examination:

Oral examination will be based on entire subject.

Term Work:

Term work consists of minimum six experiments/assignments and a written test. The distribution of the term work shall be as follows,

Laboratory work (Experiments and Journal) :15 marks
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

Text Books:

1. Stamatios V. Kartalopolous, "Understanding Neural Network and Fuzzy Logic", PHI Pvt Ltd.

2. Kishan Mehrotra, "Elements of ANN", 2nd Editon, Penram International Publishing (I) Pvt. Ltd.

Reference Books:

1. Donald A. Waterman, “A Guide to Expert Systems”, Addison-Wesley Publishing Company.

University of Mumbai			
Class: B.E.	**Branch:** Instrumentation Engineering	**Semester:** VIII	
Subject : Batch Process Automation (Abbreviated as BPA)			
Periods per Week (60 min. each)	Lecture	04	
	Practical	02	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory	03	100
	Practical & Oral	---	25
	Term Work	---	25
	Total	---	150

Module	Contents	Hours
1	**Introduction to Batch Processes** 1.1 Types of manufacturing processes- Discrete, Batch and Continuous ones. 1.2 Examples of Batch Process Industries 1.3 Definition and characteristics of Batch Processes 1.4 Typical Batch Process Equipments- Batch reactor, Blenders and Mixers, Agitators, Transport Headers, Heat Exchangers, Batch Distillation Columns, Pumps and Valves. 1.5 Typical Batch Process Operations-- Filling of Bulk materials, Additives & Solids, Heating, Cooling and Maintenance of Temperature, Mixing by Agitation & Circulation. 1.6 Quality Analysis Automation Requirements of Batch Processes – Measurement, Closed Loop Control, Sequential Control, Reporting 1.7 Role of Humans in Batch Process Control	7
2	**ISA S88 Batch Standard** 2.1 Introduction to ISA S88 Batch Standard 2.2 ISA S88 Physical Modeling	**3**
3	**Recipes** 3.1 Definition 3.2 Recipe Types – General, Site, Master and Control Recipes 3.4 Recipe Content – Header, Formula, Procedure **3.5** Recipe Management	**4**
4	**Batch Execution using Batch Management Software** 4.1 Creating Master Databases – Equipment, Material 4.2 Creating Physical Model	**5**

	4.3 Creating new recipes, modifying existing recipes 4.4 Downloading recipes to control system 4.5 Batch Operation 4.6 Storing of Batch Historical Data	
5	**Production Planning and Batch Scheduling** 5.1 Production plan 5.2 Equipment Availability 5.3 Resource Constraints 5.4 Batch Scheduling 5.5 Batch Historical Data	**5**
6	**Typical Control Schemes for Batch Processes** 6.1 Temperature Control of Batch Reactors 6.2 Set Point Programmer 6.3 Raw Material Charging – Bulk Liquids, Solids, Additives, and Controlled Addition(fixed flow rate) 6.4 Operation of motors and automated on-off valves	**4**
7	**Control System Architectures for Batch Processes** 7.1 Use of industrial bus networks – Asi, Devicenet, Modbus, Profibus, Canopen, Ethernet TCP/IP 7.2 Intelligent sensors and transmitters, Intelligent motor starters, soft starters and VFDs 7.3 Communication with third party intelligent devices 7.4 Open Architecture systems 7.5 Centralized vs. Distributed Control	**5**
8	**Data Analysis and Reporting** 8.1 Real Time and Batch wise data 8.2 Historian Server – MS SQL Server 8.3 Data Analysis Clients – Excel, Web based Types of Reports – Batch Log Sheet, Raw Material Consumption Report, Equipment Utilization Report, Quality Analysis Reports, Batch to Batch Analysis of KPIs 8.4 Report Formats – Tabular, Graphical, Pie Chart, Bar Chart etc.	**5**
9	**MES and Integration with ERP Systems** 9.1 Overview of Manufacturing Execution Systems (MES) and Enterprise Resource Planning (ERP) Systems 9.2 Objectives and Benefits of MES 9.3 Overview of ISA S95 Standard "Enterprise – Control System Integration" 9.4 Application Study of Integration with ERP System	**4**
10	**Special Requirements for Pharmaceutical and Food Industries.** 10.1 Validation requirements 10,2 GAMP Procedures 10.3 21CFR11 Compliance	**4**

Theory Examination:

1. Question paper will consist of total 7 questions carrying 20 marks each.
2. Only 5 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.

Practical and Oral Examination:

Practical examination will be based on one experiment performed from the list of experiments given below and the oral will be based on entire subject.

Term Work:

Term work consists of minimum 8 experiments, written test, report of industrial visit to pharmaceutical or food processing industry and object oriented visit to systems integrator. The distribution of the term work shall be as follows,

Laboratory work (Experiments and Journal) :15 marks
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

List of Practical Experiments:

1. Charging of Liquid Raw Materials – By Flow meter, Level and Load cell based weighing system
2. Study of Temperature Control of a Batch Reactor
3. Study of set point programmer, heating, cooling and temperature maintenance
4. Remote operation of motors and valves
5. Preparing a Plant Model based on ISA S88
6. Writing a recipe for a batch process
7. Programming a batch sequence in PLC/ DCS
8. Study of Batch Reports
9. Running a typical batch process using PLC/ DCS on the Batch Reactor set up
10. Comparison of actual batch parameters with standard.

Text Books:

1. Thomos Fisher, “Batch Control Systems, Design, Application and Implementation”, ISA.
2. ISA S88 Standards Booklet
3. Bela G. Liptak “Instrument engineers handbook- Process control” Chilton book company- 3rd edition.

University of Mumbai		
Class: B.E.	**Branch:** Instrumentation Engineering	**Semester:** VIII
Subject: Instrumentation Project Documentation and Execution(abbreviated as IPDE)		

Periods per Week (60 min. each)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	**Marks**
Evaluation System	Theory	03	100
	Oral	---	25
	Term Work	---	25
	Total	--	150

Module	Contents	Hours
1	**The Project**: Introduction, predictability, structure, flow and deliverables, Project Planning, Scheduling and Procurement methods and procedures.	8
2	**The Project Team**: Customer, designer and constructer	2
3	**Documents to be designed.** 1. Piping and Instrumentation diagrams (P&ID) - General description, purpose, contents and practical applications. 2. Instrument Index Sheet 3. Instrument specifications sheet- for temperature, pressure, level, flow instruments and control valves. 4.Instrument Location Plan 5.Cable and Tray Routing 6.Cable Schedule 7. JB Schedule 8. Air header schedule 9. Instrument Hook- up diagrams 10. BoM for erection 11. Loop diagrams- pneumatic, electronic and digital data types. 12.DCS/ SCADA graphics 13. Logic diagrams.	18
4	**Systems Integration:** Division of labor, 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, Factory acceptance test (FAT), Site acceptance test(SAT),	8

	commissioning, Operations and maintenance(O&M) manual, and onsite training.	
5.	**Installation Practices-** cable laying (cable trays, cable types**,** cable glands), tubing, instrument installation, loop checking, calibration, testing and commissioning Procedures. **Standards used in instrumentation project:** ISA, ANSI, & NFPA.	8
6.	Advantages of using software packages for documentation. Survey of documentation software packages used in industry viz Intools, EPlan etc.	4

Theory Examination:

1. Question paper will consist of total 7 questions carrying 20 marks each**.**
2. Only 5 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.

Oral Examination:

Oral examination will be based on entire subject and visits.

Term Work:

Term work consists of a written test and following tasks:
1. Case study documents on AutoCAD
2. Visit to engineering consulting organizations like Uhde, KPG, Jacob Engg., Mod Mcdonald etc.
3. Survey of commercial software for documentation and study their special features e.g. INTOOLS, Auto-studio, Smart Plant Automation, Eplan.
4. Study of ISA standard Specification Sheet such as transducer, transmitter, controller and control valve.
5. Study of Planning and Scheduling software like MS project.

The distribution of the term work shall be as follows,
Laboratory work (Experiments and Journal) :15 marks
Test (at least one) :10 marks

Text Books:

1. Andrew Williams, "Applied instrumentation in the process industries", 2nd Edition, Vol. 2, Gulf publishing company.

2. Whitt, Michael D., “Successful Instrumentation and Control Systems Design”, ISA Publication.
3. Thomas McAvinew and Raymond Mulley, “Control System Documentation”, 2nd Edition, ISA Publication.

Reference Books:

1. NJATC, “Basics of Instrumentation”, Cengage Learning.
2. Chinttan, Hiral Shah,” Project planning and Engineering”, Chinttan Publication

University of Mumbai		
Class: B.E	**Branch:** Instrumentation Engineering	**Semester:** VIII

Subject: Instrument & System Design(abbreviated as ISD)

Periods per Week (60 min.each)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	**Marks**
Evaluation System	Theory	03	100
	Oral	---	25
	Term Work	---	25
	Total	--	150

Module	Contents	Hours
1	**Design of Transducers:** An overview of static and dynamic performance characteristics of instruments. Selection criteria for flow, temperature, level, and pressure transducers. Design considerations for transducers such as thermocouple, RTD, orifice plates, Calibration and installation procedure for thermocouple and RTD,.	05
2	**Design of Instrument Air Systems**: Quality of instrument air, Sizing criteria. Air supply source, compressor systems. Air distribution system. Control room air supply and air handling. Air dryers.	03
3	**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
4	**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. Packing, Pressurized panels- X, Y, and Z Purging for installation in hazardous areas. Ex-proof panels.	08
5	**Electronic product design:** System Engineering, ergonomics, phases involved in electronic product design.	04
6	**Reliability engineering:** Reliability concepts, bath tub curve, MTTF, MTBF, and MTTR.	03

	Quality and reliability. Causes of failures. Availability and Maintainability. Redundancy and redundant systems.	
7 8	**Control Room Design:** Layout and environment. **Enclosure Design :** Packing and enclosures design guidelines, Grounding and shielding, front panel and cabinet design of an electronic product.	04 05

Theory Examination:

1. Question paper will consist of total 7 questions carrying 20 marks each**.**
2. Only 5 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.

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

Term Work:
Term work consists of minimum six assignments and written test. The distribution of the term work shall be as follows,
Laboratory work (Experiments and Journal) :15 marks
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

Text Books :

1. Bela G. Liptek, "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.

University of Mumbai			
Class: BE	**Branch:** Instrumentation Engineering	**Semester-** VIII	
Elective-II: Power Plant Instrumentation (Abbreviated as PPI)			
Periods per Week (each 60 min)	Lecture	4	
	Practical	2	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory	3	100
	Oral	--	25
	Term Work	--	25
	Total	--	150

Module	Contents	Hours
1	Energy sources, their availability, worldwide energy production, energy scenario of India. Introduction to Power generation- Classification: Renewable and nonrenewable energy generation resources. Renewable: small hydro; modern biomass; wind power; solar; geothermal and bio-fuels. Nonrenewable: fossil fuels (coal, oil and natural gas) and nuclear power.	04
2	**Boiler**: Types of boilers, boiler safety standards. Boiler instrumentation, control and optimization, combustion control, air to fuel ratio control, three element drum level control, steam temperature and pressure control, boiler interlocks, sequence event recorder, data acquisition systems	08
3	**Thermal Power Plant**- Method of power generation, layout and energy conversion process, Types of Turbines & control, Types of Generators, condensers. Types of pumps and Fans, variable speed pumps and Fans, Material handling system, study of all loops-water, steam, fuel etc.	07
4	**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
5	**Wind Energy**: Power in wind, Conversion of wind power, Aerodynamics of wind turbine, types of wind turbine, and modes of operation, power control of wind turbines, Betz limit, Pitch & Yaw control, wind mill, wind pumps, wind farms,	08

	different generator protections, data recording, trend analysis, troubleshooting & safety.	
6	**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.	05
7	**Nuclear Power Plant:** Nuclear power generation, control station and reactor control	06
8	Comparison of 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 standards, pollution, effluent management and handling. Power plant safety, Pollution monitoring, control Sound, Air, smoke, dust, study of Electrostatic precipitator.	04

Theory Examination:

1. Question paper will comprise of total 7 questions, each of 20 marks.
2. Only 5 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
6. No question should be asked from the pre-requisite module

Oral Examination:

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

Term work:

Term work consists of minimum eight experiments/assignments, industrial visit report and a written test. The distribution of the term work shall be as follows,

Laboratory work (Journal) :15 marks
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.

Text Books:

1. "Boiler Control Systems Engineering", by G.F. Gilman, 2005, ISA Publication.
2. "Power plant engineering", P.K.Nag, 3rd edition, 2010. McGraw Hill.

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. Energy Management Handbook: W.C. Taeruer
7. Pollution: M.N.Rao and H.V. Rao.
8. Power system control Technology – Torsten Cegrell (PMI)
9. Energy Technology Handbook, considine D.M.(MHR)
10. Solar Energy Technology vol I & II Dickinson & cheremision off.
11. Wind Energy Handbook**,** Tony Burton, David Sharpe, Nick Jenkins, Ervin Bossanyi (2001), John Wiley & Sons, ISBN: 0471489972,
12. Wind Energy Explained: Theory, Design and Application
by James Manwell, J. F. Manwell, J. G. McGowan (2002), John Wiley and Sons Ltd, ISBN: 0471499722
13. Wind Turbine Operation in Electric Power Systems, Z. Lubosny (2003), Springer-Verlag New York, Inc ; ISBN: 354040340X.
14. David Lindsey, “Power Plant control and instrumentation – control of boilers HRSG”, Institution of Engineering and Technology.

University of Mumbai			
Class: B. E.	**Branch:** Instrumentation Engineering	**Semester:** VIII	
Elective-II: Digital Control System (DCS)			
Periods per Week (each 60 min)	Lecture	4	
	Practical	2	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory Examination	3	100
	Oral Examination	--	25
	Term Work	--	25
	Total	--	150

Module	Contents	Hours
1	**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.	02
2	**Signal conversion and processing** Digital signal coding, data conversion and quantization, sampling period considerations, sampling as impulse modulation, sampled spectra & aliasing, Reconstruction of analog signals, zero order hold, first order hold, frequency domain characteristics, principles of discretization- impulse invariance, finite difference approximation of derivatives, rectangular rules for integration, Bilinear transformation, Mapping between s-plane & z-plane.	08
3	**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
4	**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.	08
5	**State space analysis** Discrete time state equations, significance of Eigen values & Eigen vectors, first and second companion form, Diagonalisation, Jordan Canonical form, similarity	18

	transformation, state transition matrix, solution of discrete time state equation, Discretization of continuous state space model & its solution. Liyapunov stability analysis, definitions, theorem, concept of equilibrium state.	
6	**Pole placement and observer designs** Concept of reachability, Controllability, Constructability & Observability, Design of controller via Pole placement method, state observer design, dead beat controller design, concept of duality.	08

Theory Examination:

1. Question paper will consist of total 7 questions carrying 20 marks each.
2. Only 5 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
6. No question should be asked from the pre-requisite module

Oral Examination:

Oral examination will be based on entire subject.

Term work:

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

Laboratory work (Experiments and Journal) :15 marks
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.

List of Laboratory Experiments:

1. Determine the range of sampling period for stability of the system.
2. Effect of dead time on system performance.
3. To determine response of zero order hold and first order hold using simulink of MATLAB.
4. Mapping from S- plane to Z-plane analytically and verification using MATLAB or any other suitable software.
5. 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.
6. To represent given system in different canonical forms, analytically and verification using MATLAB or any other suitable software.
7. To determine pulse transfer function of a given system analytically and its verification using MATLAB or any other suitable software.

8. Determination of state transition matrix analytically and its verification using MATLAB or any other suitable software.
9. To check controllability and observability of a given system analytically and verify the result using MATLAB or any other software.
10. To plot pole-zero map of a discrete system and comment on response and stability.
11. To design the controller using –
    i) Transform method
    ii) Ackerman's Formula

Analytically and verification using MATLAB or any other suitable software.
12. To design an observer using –
    i) Transform method
    ii) Ackerman's Formula

Analytically and verification using MATLAB or any other suitable software.
13. To design deadbeat controller and observer using any method analytically and verification using MATLAB or any other suitable software.
14. To check stability of given system using Lyapunov theorem.

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.

Text Books:

1. M. Gopal, "Digital Contol and State Variable Methods", Tata McGraw Hill, 2nd Edition, March 2003.
2. K. Ogata, "Discrete Time Control Systems", Pearson Education Inc., 1995.
3. B.C. Kuo, "Digital Control Systems", Saunders College Publishing, 1992.

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 MATLAB", Thomson Learning, 1st Edition, 2003.
4. Eronini Umez, "System Dynamics and Control", Thomson Learning, 1999.
5. Franklin Powel, "Digital Control of Dynamic Systems", Pearson Education, 3rd Edition, 2003.
6. Digital Control Systems vol. I & II - Isermann, Narosa publications

University of Mumbai			
Class: B. E.	**Branch:** Instrumentation Engineering	**Semester:** VIII	
Elective-II: Optimal and Robust Control Systems (Abbreviated as ORCS)			
Periods per Week (each 60 min)	Lecture	4	
	Practical	2	
	Tutorial	-	
		Hours	Marks
Evaluation System	Theory Examination	3	100
	Oral Examination	--	25
	Term Work	--	25
	Total	--	150

Module	Contents	Hours
Prerequisite	Partial differentiation, gradient and gradient vector, solving differential equations of multi-order, integral calculus etc.	01
1	**Introduction:** The basic concepts of optimal control, formulation of optimal control problem, performance criteria.	02
2	**Parameter Optimization:** parameter optimization for servo systems (tracking problem), optimal control problem using transfer function approach for continuous and discrete time control system, output regulator problem.	05
3	**Linear Regulators:** Linear quadratic regulator problem, Derivation of Riccati equation for continuous and discrete time systems. State regulator, output regulator and tracking regulator problem for continuous and discrete time control system with examples.	10
4	**Dynamic Programming:** Principles of optimality, derivation of Hamilton – Jacobi - Bellman equation, Application of optimal control via dynamic programming for continuous and discrete time systems.	10
5	**Calculus of Variation:** Minimization of functions, minimization of functionals, fixed end point and variable end point problems, formulation of variational calculus problem using Hamiltonian method.	14
6	**Introduction to Robust Control System** Robust control system and system sensitivity, analysis of robustness, systems with uncertain parameters. Types of uncertainties: additive and multiplicative with examples. Design of robust control systems using worse case polynomial and Routh-Hurwitz criteria.	06

Theory Examination:

1. Question paper will comprise of total 7 questions, each of 20 marks.
2. Only 5 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
6. No question should be asked from the pre-requisite module

Oral Examination:

Oral examination will be based on assignments on each Module given in the syllabus and the oral will be based on entire subject.

Term work:

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

Laboratory work (Experiments and Journal) :15 marks
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.

Assignments: Each student shall perform at least **08** assignments based on the above syllabus. Out of which at least **Four** assignments must be performed by using simulation software like MATHCAD/MATLAB/SCILAB.

Books Recommended:

Text Books:

1) D. Kirk, "Optimal Control – An Introduction", Prentice Hall, Inc., Englewood Cliff, N. J., 1970.
2) M. Gopal, "Modern Control System Theory", Wiley Eastern, 1982.
3) Anderson B. D. O. and J. B. Moore, "Linear Optimal Control", Prentice Hall, Englewood Cliff, N. J., 1971.
4) R.C. Dorf, R.H. Bishop, "Modern Control Systems", 8th Edition, Addison Wesley, 1999.

Reference Book:

1) Athens and Faib, "Optimal Control".
2) Petros A. Joannou and Jing Sun, "Robust Adaptive Control", Prentice Hall Inc, 1996.

University of Mumbai			
Class: B.E.	**Branch:** Instrumentation Engineering	**Semester:** VIII	
Elective-II: Nuclear Instrumentation (abbreviated as NI)			
Periods per Week (60 min. each)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	03	100
	Oral	--	25
	Term Work	---	25
	Total	---	150

Module	Contents	Hours
1	**Radioactivity :** General Properties of Nucleus, Radioactivity ,Nature of Nuclear Radiation's, Characteristic properties of radioactive 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.	08
2	**Radiation detectors :** Techniques for weak signal detection, Detectors for Alpha, beta and gamma rays, Detector classification – Ionization chamber, Regions of multiplicative operation, Proportional counter, Geiger Muller counter-volt ampere characteristics, Designing features, Scintillation detectors (Photomultiplier tube- types, dark currents, scintillators, pulse resolving power) , efficiency of detection, SNR improvement, Solid state detectors (Lithium ion drifted - Si-Li, Ge-Li, Diffused junction, surface barrier)	08
3	**Electronics and Counting systems** : Pre-amp., main amplifiers, Discriminators, Scalars and count rate meters, Pulse shaping, pulse stretchers, Coincidence circuits, photon	08

	counting system block diagram, factors influencing resolution of gamma energy spectrum, Energy resolution in radiation detectors, single and multichannel analyzers **(MCA)**,pulse height analyzers **(PHA)**.	
4	**Application in Medicines:** Gamma camera- design, block diagram, medical usage. Radiation uptake studies- block diagram and design features. Nuclear Instrumentation for health care, Radiation Personnel Health Monitors like neutron monitors, Gamma Monitors, Tritium monitors, Iodine monitors and PARA (particulate activity radiation alarms).	10
5	**Applications in Industry:** Basic Nuclear Instrumentation system- block diagram, Nuclear Instrumentation for laboratory. Personal monitors like Thermo Luminescence Detectors (TLD), Dosimeters, Tele-detectors, which are used to assess the radiation exposure to the radiation plant workers. Nuclear Instrumentation for power reactor. Nuclear Instrumentation for Toxic fluid tank level measurement, Underground Piping Leak detection, weighing, thickness gauges, water content measurement etc. Agriculture applications like food irradiation.	14

Theory Examination:

1. Question paper will consist of total 7 questions carrying 20 marks each.
2. Only 5 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.

Oral Examination:

Oral examination will be based on entire subject.

Term work:
Term work consists of minimum three experiments (from the list given below) and ten assignments based on entire subject. The distribution of the term work shall be as follows,
The distribution of the term work shall be as follows,
Laboratory work (Experiments / Journal / Assignments) :15 marks
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.

List of Experiments
Experiment No.1: 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.
Experiment No.2: 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, operating voltage and slop of plateau.
Experiment No.3: To study the Gamma Ray Spectrometer.
Purpose**:** The purpose is to understand the functioning and working of Spectrometer.
Experiment No.4: To obtain the spectrum of Gamma emitting isotope Cs 137 by using scintillator spectrometer.
Experiment No.5: To obtain the spectrum of Gamma emitting isotope Co 60 by using scintillator spectrometer.
Experiment No.6: To study the energy calibration of Spectrometer and analysis of the energy of unknown Gamma source.

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 Eastern 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, TMH Publishing New Delhi, 1974.

University of Mumbai			
Class: B.E.	**Branch:** Instrumentation Engineering	**Semester:** VIII	
Elective-II: Automation in Energy and Infrastructure (Abbreviated as AEI)			
Periods per Week (60 min. each)	Lecture	04	
	Practical	02	
	Tutorial	--	
		Hours	Marks
Evaluation System	Theory	03	100
	Oral	---	25
	Term Work	---	25
	Total	---	150

Module	Contents	Hours
1	**Energy Management** **1.1** Need for Energy Management **1.2** Impact on Environment **1.3** Energy Efficiency **1.4** Role of Automation in Energy Management	3
2	**Energy Monitoring** **2.1** Definitions and Significance of Electrical parameters – Current, Voltage, Frequency, Power, Energy, Power Factor, Maximum Demand, and Harmonics **2.2** CTs and PTs – their types and selection Transducers for Current, Voltage, Frequency, Power, Energy, Power Factor **2.3** Intelligent Power Monitoring Units, Relays, Switchgear devices **2.4** RTUs, PLCs for data concentration and processing **2.5** SCADA for Energy Monitoring Applications in Electrical Substations, Factories, Data Centers, and Buildings	7
3	**Energy Audit** **3.1** Need for Energy Audit **3.2** Methodology adopted for Energy Audit	4
4	**Building Management Systems (BMS)** **4.1** Scope of BMS **4.2** Difference between BMS and PCS (Process Control System)	5
5	**Automation of HVAC Systems**	7

	5.1 Major Equipments in HVAC Systems – Chillers, Blowers, Air Handling Units, Dehumidifiers, Filters **5.2** Need for Automation in HVAC – Energy Saving, Quality of environment **5.3** Typical HVAC parameters, their measuring instruments, operating principles, specifications limitations and installation practices – Temperature, RH, Pressure and Differential Pressure, Air Velocity Motorized on-off valves, dampers and control valves used in HVAC applications **5.4** Energy saving with VFDs on Pumps and Blowers **5.5** DDC/ PLCs for monitoring and control **5.6** Typical Control Schemes **5.7** SCADA for BMS	
6	**Fire Monitoring Systems** **6.1** Smoke and Fire Detectors – Types and Selection **6.2** Fire Detection Systems	**4**
7	**Security and Surveillance** **7.1** Access Control – Simple, Biometric, RFID, Barcode **7.2** CCTV Systems – Types of CCTV Cameras and their selection for different applications, CCTV monitoring systems	**5**
8	**Other BMS Topics** **8.1** Lighting Control **8.2** Control of Elevators, Escalators **8.3** PA Systems	**5**
9	**Cabling in BMS** **9.1** Types of Cable – Signal Cables, Control Cables, Power Cables, Bus Cables, Ethernet Cables – UTP and Fiber Optic **9.2** Cabling Accessories – Cable Trays, Ducts, glands, connectors, **9.3** Cable laying practices	**4**
10	**BMS Application Examples** **10.1** Shopping Malls **10.2** Hotels **10.3** Commercial Complex **10.4** Hospitals **10.5** Airports	**4**

Theory Examination:

1. Question paper will consist of total 7 questions carrying 20 marks each.
2. Only 5 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.

Oral Examination:

Oral examination will be based on entire subject.

Term Work:

Term work consists of minimum six assignments, a written test and a report of visit to any one of the sites mentioned in module No 10. The distribution of the term work shall be as follows,

Laboratory work (Experiments and Journal) :15 marks
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

Text Books :

1. "Engineering Manual For Automatic Control For Commercial Buildings" Honeywell, SI Edition, 1997.

2. CIBSE Guide H, "Building Control Systems", Butterworth Hienemann.

Reference Books :

1. Reinhold A. Carlson Robert A. Di Giandomenico, "Understanding Building Automation Systems: Direct Digital Control, Energy Management, Life Safety, Security Access Control, Lighting, Building", 1st edition (R.S. Means Company Ltd), (1991)
2. Levenhagen John"HVAC control system Design Diagrams",Mcgraw Hill
3. Invensys Building systems
4. Audel HVAC Fundamentals,Vol 1