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

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)							
		Internal Assessment (out of 20)			End sem Exam	Term Work	Pract. and oral	Oral	Total
		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)							
		Internal Assessment (out of 20)			End sem Exam	Term Work	Practical	Oral	Total
		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)							
		Internal Assessment (out of 20)			End sem Exam	Term Work	Pract. and oral	Oral	Total
		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 - Integration 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)