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:** 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