

UNIVERSITY OF MUMBAI
SCHEME OF INSTRUCTIONS AND EXAMINATION
at
B.E. (Instrumentation Engineering) - (R-2001)

SEMESTER VIII

Sr. No.	Subjects	No. of Periods per Week			Duration of Theory Paper (Hrs.)	Marks				
		Lectures	Practicals	Tutorials		Paper	Term Work	Practical	Oral	Total
1	Biomedical Instrumentation	4	2	-	3	100	25	-	25	150
2	Digital Control Systems	4	2	-	3	100	25	25	25	175
3	Instrumentation System Design	4	2	-	3	100	25	-	25	150
4	Elective II*	4	2	-	3	100	25	-	25	150
5	Project II	-	8	-	-	-	50	-	50	100
Total		16	16	-	-	400	150	-	150	725

*Robotics elective is common with Electronics, Electrical, IT, and Computer Engineering branches.

Biomedical Instrumentation

Lectures per week: 4

Practicals per week: 2

Paper: 100 marks, Duration: 3 hours

Term Work: 25 marks

Oral: 25 marks

1. **Human Body System Overview:** Structure of cell, respiratory system, nervous system, nerve muscle physiology, circulatory system.
2. **Cell activity and Origin of Bio-potential:** Origin of biopotential, electrical activity of cell, action potential and its propagation, origin of EMG, EEG, ECG, ERG and EOG.
3. **Measurement of Biochemical and Bioelectric Potential:** Biochemical measurements - pH, PO₂, PCO₂, different types of electrodes, electrode-electrolyte interface, biopotential amplifier and its characteristics, measurement of biopotential using EEG, EMG and ECG (block diagram based).
4. **Cardiovascular Measurements:** Blood flow, blood pressure, plethysmographs and their types, cardiac output, oxymeter, heart sound measurement.
5. **Therapeutic Instruments:** Pacemaker, defibrillator, heart lung machine, dialysis system, surgical machine, incubator, ventilator.
6. **Imaging Techniques:** X-ray generation and X-ray machine, CT-scanning, ultrasound imaging, magnetic resonance imaging, nuclear medicine (gamma camera) and their applications.
7. **Significance of Electrical Danger:** Physiological effect of electric current, shock hazards and accident prevention.

Experiments:

1. To study ECG.
2. To study EMG.
3. To study EEG.

4. To study phonocardiograph.
5. To measure blood pressure.
6. To study heart rate indicator.
7. To study X-Ray machine.
8. To study dialysis machine.
9. To study plethysmograph.
10. To measure heart rate.

Term Work: Each student shall appear for at least one written test during the term. The journal should consist of at least 6 experiments/assignments properly recorded and graded as well as the assessed test paper. The term work will carry a weightage of 25 marks. Distribution of marks: 10 marks for the journal, 10 marks for the test, and 5 marks for attendance.

Text Books:

1. Leslie Cromwell, "Biomedical Instrumentation and Measurements", 2nd Edition, Pearson Education, 1980.
2. R.S. Khandpur, "Biomedical Instrumentation", TMH, 1994.

Reference Books:

1. Richard Aston, "Principles of Biomedical Instrumentation and Instruments"
2. Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment Technology", PHI/Pearson Education, 4th Edition, 2001.
3. John G. Webster, "Medical Instrumentation", John Wiley and Sons, 1999.

Digital Control Systems

Lectures per week: 4

Practicals per week: 2

Paper: 100 marks, Duration: 3 hours

Term Work: 25 marks

Oral: 25 marks

Practical: 25 marks

1. **Introduction:** Advantages of digital control systems, examples of discrete data and digital control systems.
2. **Signal Conversion and Processing:** Digital signals and coding, data conversion and quantisation, sample and hold devices, sampling period considerations, sampling as impulse modulation, sampled spectra and aliasing, reconstruction of analog signals, zero order hold, first order hold, frequency domain characteristics, principles of discretisation - impulse invariance, finite difference approximation of derivatives, rectangular rules for integration.
3. **Representation of Digital Control Systems:** Linear difference equations, pulse transfer function, input-output model, examples of first order continuous and discrete time systems, signal flow graph applied to digital systems, mapping between s-plane and z-plane. Bilinear Transformation.
4. **Stability of Digital Control Systems in z-Domain:** Jury's method, R.H. criteria root locus technique, frequency response method.
5. **Time Domain Analysis:** Comparison of time response of continuous data and digital control systems. Steady state analysis of digital control systems. Effect of sampling period on transient response characteristics.
6. **State Space Analysis:** Discrete time state equations, state diagram, similarity transforms, eigenvalues, eigenvectors, first and second companion form, diagonalisation, Jordan Canonical

Form, solving the discrete time state equation, state transition matrix, discretisation of continuous time systems.

Term Work: Each student shall appear for at least one written test during the term. The journal should consist of 10 assignments/experiments out of which 5 must be done with the help of simulation software MATLAB/MATHCAD/PSPICE/SCILAB or a similar one. Term work will carry a weightage of 25 marks. Distribution of marks: 10 marks for the journal, 10 marks for the test and 5 marks for attendance.

Text Books:

1. M. Gopal, "Digital Control 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.

Instrumentation System Design

Lectures per week: 4

Practicals per week: 2

Paper: 100 marks, Duration: 3 hours

Term Work: 25 marks

Oral: 25 marks

1. **Design of Transducer:** An overview of static and dynamic performance characteristics of instruments. Design considerations for transducers such as thermocouple, RTD, orifice plates, rotameter, LVDT etc. Calibration and installation procedure for thermocouple, RTD etc.
2. **Design of Control Valve:** Review of flow equations. Valve selection and sizing for liquid service, gas or vapour service, flashing liquids, mixed phase flow. Control valve noise. Control valve cavitations. Actuator sizing.
3. **Design of Instrument Air Systems:** Sizing criteria. Air supply source, compressor systems. Air distribution system. Control room air supply and air handling. Design of safety relief valves and rupture discs.
4. **Design and Architectural Overview of Programmable Logic Controllers:** Input output system - discrete I/O modules, analog I/O modules, special purpose modules, intelligent I/O modules, communication modules. Basic and advanced PLC. Programming - PLC programming standards, ladder diagram language and instruction set, advanced function block instructions, structured text language, function block diagram language, sequence function chart language. PLC system design and applications.
5. **Electronic Product Design:** System engineering, documentation, human interface such as ergonomics, aesthetics. Packing and enclosures, grounding and shielding, front panel and cabinet design of an electronic product.

Term Work: Each student shall appear for at least one written test during the term. The journal should consist of 6 assignments/practicals graded as well as the assessed test paper. The term work will carry 25

marks. Distribution of marks: 10 marks for the journal, 10 marks for the test and 5 marks for attendance.

Text Books:

1. Nakra and Chaudhary, "Instrumentation Measurements and Analysis", TMH-1992.
2. Bela G. Liptak, "Instrument Engineer's Handbook - Process Control", Chilton Company, 3rd Edition, 1995.
3. Andrew Williams, "Applied Instrumentation in Process Industries", 2nd Edition, Vol. 3, Gulf Publishing Company.

Reference Books:

1. R.W. Zape, "Valve Selection Handbook", 3rd Edition, Jaico Publishing House
2. Les Driskell, "Control Valve Sizing", ISA.
3. Thomas A. Hughes, "Programmable Controllers", 2nd Edition, ISA.
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

Elective II: Image Processing

Lectures per week: 4

Practicals per week: 2

Paper: 100 marks, Duration: 3 hours

Term Work: 25 marks

Oral: 25 marks

1. **Introduction:** Definition of image, generation of image, steps in image processing, elements of digital image processing systems, image enhancements, restoration and analysis.
2. **Digital Image Fundamentals:** Elements of visible perception, image model, sampling and quantisation, relationships between pixels, imaging geometry.
3. **Image Transforms:** Introduction to DFT, 2D DFT, FFT, other separable image transforms (walsh, hadamard, discrete cosine, haar, slant, KL)
4. **Image Enhancements:** Point operations, histogram modeling, spatial filtering - smoothing, sharpening, low pass, high pass, homomorphic filtering.
5. **Image Restoration:** Image observation models, inverse and wiener filtering, FIR wiener filters, filtering using image transforms, least squares filters, generalised inverse, SVD and interactive methods, recursive filtering, causal models, digital processing of speckle images, maximum entropy restoration.
6. **Image Segmentation:** Detection of discontinuities, edge linking and boundary detection, thresholding region oriented segmentation, use of motion in segmentation.
7. **Image Data Compression:** Introduction, pixel coding, predictive techniques (PCM, DPCM etc.), transform coding theory of images, hybrid coding and vector DPCM.

List of Experiments:

1. Program for 2d convolution.
2. Image rotation, scaling and translation.
3. Program for 2d correlation.
4. Program for 2d FFT.
5. Program for discrete cosine transform.
6. Program for KL transform.
7. Program for histogram equalisation and histogram specification.

8. Program for mask operation (spatial filtering).
9. Program for edge detection.
10. Program for thresholding.
11. Function for determining boundary descriptors like boundary length and curvature.

Term Work: Each student shall appear for at least one written test during the term. The journal should consist of 8 graded practicals as well as the assessed test paper. The term work will carry 25 marks. Distribution of marks: 10 marks for the journal, 10 marks for the test and 5 marks for attendance.

Text Books:

1. Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", Pearson Education, 2nd Edition, 1999.
2. A.K. Jain, "Fundamentals of Digital Image Processing", PHI, 2nd Edition, 1995.
3. W.K. Pratt, "Digital Image Processing", John Wiley and Sons, 1994.

Reference Books:

1. C. Phillips, "Image Processing in C", BPB Publication, 1995.
2. B. Chanda, D. Dutta Majumdar, "Digital Image Processing", PHI, 2000.
3. Emmanuel C. Ifeachor and Barry W. Jervis, "Digital Signal Processing", Pearson Education, 2nd Edition, 2000.
4. Don Pearson, "Image Processing" - The ESSEX series in telecommunication and information systems, McGraw Hill International ETL engineering series, 1991.
5. Johnny Johnson, "Introduction to DSP", PHI, 1996.
6. Proakis, "DSP", PHI, 1997.
7. Rabnier Gold, "Theory and Application of DSP", PHI, 1996.
8. Milan Sonka, Vaclav Hlavac, "Image Processing Analysis and Machine Vision", Thomson Learning, 2nd Edition, 1999.

Elective II: Nuclear Instrumentation

Lectures per week: 4

Practicals per week: 2

Paper: 100 marks, Duration: 3 hours

Term Work: 25 marks

Oral: 25 marks

1. **Radioactivity:** General properties of nucleus, radioactivity, nature of nuclear radiations, characteristic properties of radioactive radiations, properties of alpha, beta and gamma rays, natural and artificial radioactivity. 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.
2. **Radiation Detectors:** Techniques for weak signal detection, detectors for alpha, beta and gamma rays, detector classification - ionisation 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).
3. **Electronics and Counting Systems:** Pre-amp., main amplifiers, discriminators, scalars and count rate meters, pulse shaping, pulse stretchers, coincidence circuits, photon counting system clock diagram, factors influencing resolution of gamma energy spectrum, energy resolution in radiation detectors, single and multichannel analysers (MCA), pulse height analysers (PHA).

4. **Applications in Medicine:** 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).
5. **Applications in Industry:** Basic nuclear instrumentation system - block diagram, nuclear instrumentation for laboratory. Personal monitors like Thermo Luminescence Detectors (TLD), dosimeters, teletectors, which are used to assess the radiation exposure to 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.

Term Work: Each student shall appear for at least one written test during the term. The journals should consist of at least 8 assignments/practicals based on the above syllabus, properly graded and recorded, as well as the assessed test paper. The term work will carry a weightage of 25 marks. Distribution of marks: 10 marks for the journal, 10 marks for the test and 5 marks for attendance.

Text Books:

1. G.F. Knoll, "Radiation Detection and Measurement", 2nd Edition, John Wiley and 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.

Elective II: Optimal Control Systems

Lectures per week: 4

Practicals per week: 2

Paper: 100 marks, Duration: 3 hours

Term Work: 25 marks

Oral: 25 marks

1. **Introduction:** The basic concepts of optimisation, formulation of optimal control problem, performance criteria.
2. **Calculus of Variation:** Minimisation of functions, minimisation of functionals, fixed end point and variable end point problems, formulation of variational calculus problem using Hamiltonian method.
3. **Approaches for Minimisation of Performance Index:** Pontryagin's Minimum Principle - derivation and its applications to a specific class of optimal control problems. Dynamic Programming - principle of optimality, the equation of Bellman, application to discrete and continuous systems. Hamilton-Jacobi equation, relationship between the minimum principle and dynamic programming.
4. **Linear Regulator Problem:** Optimisation of linear systems with quadratic performance index - Matrix Riccati Equation, Tracking Problem. Two Point Boundary Value (TPBV) Problem - Steepest descent method and Fletcher-Powell method.

Assignments: Each student shall perform at least 10 assignments based on the above syllabus. Some or all assignments must be performed by using simulation software like MATHCAD/MATLAB/SCILAB.

Term Work: Each student shall appear for at least one written test during the term. The journal should consist of 10 assignments properly recorded and graded as well as the assessed test paper. The term work will carry 25 marks. Distribution of marks: 10 marks for the journal, 10 marks for the test and 5 marks for attendance.

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.

Reference Book:

1. Athans and Faib, "Optimal Control".

Elective II: Virtual Instrumentation

Lectures per week: 4

Practicals per week: 2

Paper: 100 marks, Duration: 3 hours

Term Work: 25 marks

Oral: 25 marks

1. **Review of Virtual Instrumentation:** Historical perspective, advantages, block diagram and architecture of a virtual instrument.
2. **Data Flow Techniques:** Graphical programming in data flow, comparison with conventional programming.
3. **Instrumentation General Purpose Buses:** GPIB/IEEE 488 concepts, embedded system buses - PCI, EISA, CPCI, USB & VXI.
4. **Addon Peripheral Cards, Selection and Applications:** ADC, DAC, DIO, DMM, waveform generator.
5. **Introduction to LABVIEW software and Addon Toolsets.**
6. **Virtual Instrumentation Programming Techniques:** VI and sub- VIs, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, string and file I/O.
7. **Applications of Virtual Instrumentation:** Process control applications, temperature data acquisition system, motion control employing stepper motor.

Term Work: Each student shall appear for at least one written test during the term. The journal should consist of 6 assignments and a mini project based on the above syllabus properly recorded and graded, as well as the assessed test paper. The term work will carry 25 marks. Distribution of marks: 10 marks for the journal, 10 marks for the test and 5 marks for attendance.

Text Books:

1. Gary Johnson, "LABVIEW Graphical Programming", 2nd Edition, McGraw Hill, 1997.
2. Lisa K. Wells and Jeffrey Travis, "LABVIEW for Everyone", PHI, 1997.
3. Skolkoff, "Basic concepts of LABVIEW 4", PHI, 1998.

Reference Books:

1. S. Gupta, J.P. Gupta, "PC Interfacing for Data Acquisition and Process Control", ISA, 2nd Edition, 1994.
2. Technical Manuals for DAS Modules of Advantech and National Instruments.
3. L.T. Amy, "Automation System for Control and Data Acquisition", ISA, 1992.

Elective II: Robotics

Lectures per week: 4
Practicals per week: 2
Paper: 100 marks, Duration: 3 hours
Term Work: 25 marks
Oral: 25 marks

1. **Robotic Manipulation:** Automation and Robots, classification, application, specification, notations.
2. **Direct Kinematics:** Dot and cross products, coordinate frames, rotations, homogeneous coordinates, link coordination arm equation (five-axis robot, four-axis robot, six-axis robot).
3. **Inverse Kinematics:** General properties of solutions tool configuration - five axis robots, three-four axis, six axis robot (inverse kinematics). Workspace fixtures, pick and place operations, continuous path motion, interpolated motion, straight line motion.
4. **Robot Vision:** Image representation, template matching, polyhedral objects, Sane analysis, segmentation (thresholding, region labelling, shrink operators, swell operators, Euler numbers, perspective transformation, structured illumination, camera calibration).
5. **Task Planning:** Task level programming, uncertainty, configuration, space, gross motion, planning, grasp planning, fine-motion planning, simulation of planar motion, source and goal scenes, task planner simulation.
6. **Moments of Inertia.**
7. **Principles of NC and CNC Machines.**

Text Books:

1. Robert Shilling, Fundamentals of Robotics - Analysis and Control, Prentice Hall of India.
2. Fu, Gonzalez and Lee, Robotics, McGraw Hill.
3. J.J. Craig, Introduction to Robotics, Pearson Education.

Additional Reading:

1. Staughard, Robotics and AI, Prentice Hall of India.
2. Grover, Wiess, Nagel, Oderey, "Industrial Robotics", McGraw Hill.
3. Walfram Stdder, Robotics and Mechatronics.
4. Niku, Introduction to Robotics, Pearson Education.
5. Klafter, Chmielewski, Negin, Robot Engineering, Prentice Hall of India.
6. Mittal, Nagrath, Robotics and Control, Tata McGraw Hill publications.

Term Work:

1. Term work should consist of at least 10 practicals and assignmetns covering the topics of the syllabus.
2. A term work test shall be conducted with a weightage of 10 marks.

Oral Examination: An oral examination is to be conducted based on the above syllabus.

Project II

Lectures per week: 4
Practicals per week: 2
Term Work: 25 marks
Oral: 25 marks

Further to Semester VII work, the students/group of students shall collect all necessary information and analyse it. The students/group shall prepare and submit a report on the project. It shall be typewritten on A4 size paper, hard-bound and prepared in the academic style. Broadly, the report shall have four parts: Introduction, literature review, data collection, experiments conducted, software implementation etc.

Acquaintance with survey and research methods and their use in conducting a systematic investigation and style of report preparation and presentation shall form the basis of evaluation.

An oral examination shall be conducted at the end of Semester VIII.
