Department of Electrical Engineering
M. Tech. in Control and Instrumentation
NETAJI SUBHASH ENGINEERING COLLEGE

Course Structure and Scheme of Evaluation

Semester	Name of the Subjects	Hrs/Week			Credits
		Lecturer	Tutorial	Practical	
1st Semester	1. Advanced Mathematical Techniques	3	1	0	4
	2. Linear Control Theory	3	1	0	4
	3. Modelling & Simulation of dynamic systems	3	1	0	4
	4. Transducer Technology	3	0	0	3
	5. Elective I (Any one) • Advanced Microprocessors & Micro controllers. • Electronic Devices and Systems • Modern Power Converters	3	0	0	3
	Sessionals :- 1. Control System Laboratory I 2. Instrumentation Laboratory I	0 0	0 0	3 3	2 2
	Total :-	**15**	**3**	**6**	**22**

Semester	Name of the Subjects	Hrs/Week			Credits
		Lecturer	Tutorial	Practical	
2nd Semester	1. Advanced Control Theory				4
	2. Process Control and Instrumentation	3	1	0	4
	3. Digital Control Systems	3	1	0	4
	4. Elective II (Any one) • Adaptive & Robust Control Systems • Soft Computing Techniques • Digital Signal Processing • Real Time Systems	3	0	0	3
	5. Elective III (Any one) • Industrial Automation and Control • Data Communication • Experimental Methods and Analysis • Ultrasonic Instrumentation	3	0	0	3
	Sessionals :- 1. Control System Laboratory II (CI 2.1 L) 2. Instrumentation Laboratory II (CI 2.2 L) 3. Seminar (CI 2.9)	0 0 0	0 0 0	3 3 3	2 2 2
	Total	**15**	**3**	**9**	**24**

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Semester	Name of the Subjects	Hrs/Week			Credits
		Lecturer	**Tutorial**	**Practical**	
3rd Semester	1. Elective IV (Any one) • Remote Sensing and Control • Robotics • Reliability and Safety Engineering • Artificial Intelligence	3	0	0	3
	2. Elective V (Any one) • Optical and Laser Instrumentation • Biomedical Instrumentation • Image Processing • Analytical Instrumentation	3	0	0	3
	Sessionals :- 1. Project (CI 3.3) 2. Seminar (CI 3.4)	 0 0	 0 0	 12 3	 8 2
	Total :-	**6**	**0**	**15**	**16**

Semester	Name of the Subjects	Hrs/Week			Credits
		Lecturer	**Tutorial**	**Practical**	
4th Semester	Project & Dissertation (CI 4.8)	-	-	-	15
	Seminar (CI 4.9)	0	0	3	3
		0	0	3	18

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SYLLABI FOR THE PROPOSED COURSE

CI 1.1

Advanced Mathematical Techniques

3-1-0 (4 credits)

Full marks: 100 Time: 3 hours

Complex Variables: Elements of set theory, Set notations, Applications of set theory, Open & Closed Sets. Review of Complex variables, Conformal mapping and transformations, Functions of complex variables, Integration with respect to complex argument, Residues and basic theorems on residues.
Numerical Analysis: Introduction, Interpolation formulae, Difference equations, Roots of equations, Solutions of simultaneous linear and non-linear equations, Solution techniques for ODE and PDE, Introduction to stability, Matrix eigen value and eigen vector problems.
Optimization Technique: Calculus of several variables, Implicit function theorem, Nature of singular points, Necessary and sufficient conditions for optimization, Elements of calculus of variation, Constrained Optimization, Lagrange multipliers, Gradient method, Dynamic programming.
Probability and Statistics: Definition and postulates of probability, Field of probability, Mutually exclusive events, Bayes' Theorem, Independence, Bernoulli trial, Discrete Distributions, Continuous distributions, Probable errors, Linear regression, Introduction to non-linear regression, Correlation, Analysis of variance.

Ref. Book:

1. Sen, M. K. and Malik, D. F.-Fundamental of Abstract Algebra, Mc. Graw Hill
2. Khanna, V. K. and Ghamdri, S. K.- Course of Abstract Algebra,Vikash Pub.
3. Halmos, T. R.-Naïve Set Theory,Van Nostrand
4. Scarborough, J. B.-Numerical Mathematical Analysis, Oxford University Press
5. Cone, S. D.-Elementary Numerical Analysis, Mc. Graw Hill.
6. Mukhopadhyay ,P.-Mathematical Statistics ,New Central Book Agency
7. Kapoor, V. K and Gupta, S.C.-Fundamental of Mathematical Statistics,Sultan Chand and Sons.
8. Uspensky, J. V.-Introduction to Mathematical Probability, Tata Mc. Graw Hill
9. Dreyfus, S. E.-The Art and Theory of Dynamic Programming –Theory and Applications, Academic Press .
10. Rao, S. S.-Optimisation Theory and Application,Wiley Eastern Ltd.,New Delhi

CI 1.2

Linear Control Theory

3-1-0 (4 credits)

3-2-0 Full marks: 100 Time: 3 hours

Dynamics and control: An overview, control system configuration, model selection, need for dynamic models, dynamic model by averaging: averaging a variable, averaging a circuit, averaging a switching function, averaging a switch.

Linearized models : Linearization, linearizing a circuit, linearizing the average switch
Feedback control: The classical LTI control configuration, nominal stability, nominal performance, robustness.

State space models: features of state space models, state variables, inputs and outputs, continuous Time models, state space models for Electrical Circuits, properties of solutions, the state property, numerical solution, the continuity property, discrete time or sampled data models. Models for controllers and interconnected systems.
Linear and piecewise models: Linearization, linearizing continuous time models. Analysis of continuous time LTI models : transform domain solution, time domain solution, piecewise LTI models, linearizing discrete time models: time domain solution, transform domain solution, transfer function and frequency response. Eigenvalue & eigenvector analysis for controllability and observability

Feed back control design : classical control design, the Nyquist stability criteria, a design approach. Using Bode plots, designing of Bode plots of the loop gain, multi loop control : State feedback: Pole placement by LTI state feedback, Nonlinear state feedback &. Digital control.

Ref.book:

1. Ogata, K.- State Space Analysis of Control Systems , Prentice Hall.
2. John G Kassakein, Martin F. Schlecht, George C. Verghese,- Principle of Power Electronics , Addision Wesley publishing company. 1991.
3. Schulz,D. G. and Melsa ,J. L.- State Functions and Linear Control Systems, McGraw Hill, NY.
4. Graham C Goodwin, Stefan F Graebe, Mario E Salgado.- Control System Design, PHI.

CI 1.3

Modelling and Simulation of Dynamic Systems

3-1-0 (4 credits)

Full marks: 100 Time: 3 hours

State variable Modelling of Continuous Dynamic Systems.
Solution methods for Nonlinear Differential equations.
Bond Graph Techniques.
Simulation Software.
Skeletal Structure of Simulation software.
Packages and Scripting Techniques.
Real-time simulation systems.
Case studies.
Qualitative Modelling.

Ref. book:

1. Nicholson, H. - Modeling Of Dynamical Systems Vol 1 & 2 , IEE Control Engineering Series , Peter Peregrinsun Ltd.

2. Chee-Mun Ong – Dynamic Simulation of Electric Machinery (Using MATLAB / SIMULINK) ,Prentice Hall PTR.

CI 1.4

Transducer Technology

3-0-0 (3 credits)

Full marks: 100 Time: 3 hours

Classification of Instrumentation Transducer. Analog/digital,active/passive,force balance.
Variable Resistance transducers. Potentiometers, strain gauges, resistance thermometers, thermistors, hotwire anemometers, ac and dc bridges and half bridges.
Variable Inductance and variable capacitance transducers. Application, ac bridge and other interfacing methods.

Special Transducers. Piezoelectric, Magnetostrictive, Electromagnetic transducers, thermo-electric sensor, semiconductor temperature sensors.
Mechanical Characteristics of transducers: Electrodynamic transducers, eddy current, damping resonance effects, design considerations.
Force balance transducers.
Static performance – sensitivity, linearity, threshold, dynamic performance – harmonic response and bandwidth, transient response, phase compensation, velocity feed back, applications.
Power system transducers**.** Voltage, current, p.f., frequency, power, var.
Analog Signal Conditioning techniques: Bridge amplifier, carrier amplifiers, charge amplifiers and impedance converters, modulation - demodulation, dynamic compensation, linearization, multiplexing and demultiplexing.
Digital Interfacing techniques**.** Interfaces, processors, code converters, linearizers.
Single transmission .Cable transmission of analog and digital signal, fibre optic signal transmission, radio, telemetry, pneumatic transmission.
Signal Display/Recording systems. Graphic display systems, storage oscilloscope, recorders-ink, thermal, UV.
Smart Sensors**.**

Ref Book:

1. Doeblin, E.O. – Measurement Systems: Application and Design, Mc Graw Hill International.
2. Patranabis, D – Sensors and Transducers, Wheeler Pub., New Delhi.
3. Murthy, D.V.S., Transducers and Instrumentation, PHI, New Delhi.
4. Swobada, G. – Telecontrol: Methods and Applications of Telemetry and Remote Control. Van Nostrand.
5. Newbert, H. K. – Instrument Transducers, Oxford University Press.

CI 1.5.1
Advanced Microprocessors

3-0-0 (3 credits)

Full marks: 100 Time: 3 hours

Internal architecture of 8086 CPU, instruction set and programming, assembly language programming on IBM PC, ROM bios and DOS utilities.
8086 basic system concepts, signals, instruction queue, MIN mode and MAX mode, bus cycle, memory interface, read and write bus cycles, timing parameters.

Input/output interface of 8086, I/O data transfer, I/O bus cycle. Interrupt interface of 8086, types of interrupts, interrupt processing. DMA transfer, interfacing and refreshing DRAM, 8086 based multiprocessing system, 8087 math coprocessor.
Typical 8086 based system configuration, keyboard interface, CRT controller, floppy disk controller, Introduction to higher bit processors, 80286, 80386, 80486, Pentium.
A typical 16 bit Microcontroller with RISC architecture and Integrated A-D converter e.g. PIC18Cxxx family: Advantages of Harvard Architecture, instruction pipeline, analog input, PWM output, serial I/O, timers, in-circuit and self programmability. Instruction set. Typical application. Development tools.

Ref.book : 1. Ray,A. K. and Bhurchandi ,K. M.- Advanced Microprocessor and

peripherals, architecture, programming and interfacing, TMH
2. Hall, D.V.- Microprocessor & Interfacing –Programming & Hardware – 8086,80286,80386,80486, , TMH
3. Rajasree, Y.- Advanced Microprocessor, , New Age International Publishers
4. .Brey,B. B.-The Intel Microprocessor 8086/8088, Pentium , Pentium Processor, PHI.
5. Ayala , K. J.-The 8086 Microprocessor, Thomson Delmar Learning.
6. Ayala, K. J.- The 8051 Microcontroller, Thomson Delmar Learning.
7. Cady ,F. M.- Microcontrollers & Microcomputers Principles of Software &Hardware Engineering. Oxford University Press
8. Tabak ,D. Advanced Microprocessors ,TMH
9. Deshmukh,-Microcontrollers : Theory and Application.TMH

CI 1.5.2

Electronic Devices and Systems

3-0-0 (3 credits)

Full marks: 100 Time: 3 hours

Special operational amplifiers: high voltage/high current, chopper and chopper stabilized amplifiers, instrumentation amplifier, isolation amplifier.
Nonlinear function circuits: limiter, log/anti-log, multiplier/divider, peak detector, comparator, true RMS/DC converter, square wave oscillators.
Timing and counting circuits: digital counters, shift register, analog and digital timers, frequency counters, PLA and PLD applications.
Sinusoidal and relaxation oscillators: phase shift, ring, Wien-bridge, tuned, quadrature oscillator, crystal oscillator and clock circuits, voltage controlled oscillators – sine, square and triangle, frequency synthesizers.
Frequency-to-voltage converters: diode pump integrator, frequency and RPM transducers. Phase and phase/frequency comparators – analog and digital.
Phase locked loops: linear model, loop response, applications of PLL.
Power semiconductor derives: special thyristors (GTO, LASCR, Triacs etc.) BJT power MOS, IGBT, MCT, power semiconductor control circuits, SMPS, UPS, inverters, switching mode amplifier.
Optoelectronic devices: photo diode/transistor, LDR, LED and LCD displays, opto-coupler, opto-interrupter, high speed detectors – PIN and avalanche photo diodes, fibre optic data link.
Active filters: types, filter approximations – Butterworth and chebyshev, filter realisations, frequency and impedance scalings, filter transformations, sensitivity, switched capacitor circuit, data conversion and acquisition – A/D and D/A converters, DVM/DMM, quantisation noise in ADCs, selection of ADCs, sample and hold circuit, multiplexer and demultiplexer, programmable gain amplifier, microprocessor interfacing techniques.

Ref. Books:
1. Sende, B.S. – Introduction to System design using Integrated Circuits, New Age International (P), New Delhi.
2. Fitchen, F.C. – Integrated Circuits and Systems, Van Nostrand, New York.
3. Seymous, -Electronic Devices and Components.

CI 1.5.3

Modern Power Converters

3-0-0 (3 credits)

Full marks: 100 Time: 3 hours

Introduction to switched mode power converters, Generalized comparison between switched mode and linear DC regulators, operation and steady state performance of Buck, Boost, Buck-Boost and Cuk Converters: Continuous conduction mode, discontinuous conduction mode and boundary between continuous and discontinuous mode of operation, out put voltage ripple calculation, effect of parasitic elements.
DC-DC converter with isolation: Fly back converters- other fly back converter topologies, forward converter, The forward converter switching transistor- Variation of the basic forward converter, Push pull converter-Push pull converter transistor-Limitation of the Push Pull circuit-circuit variation of the push pull converter-the half bridge and full bridge DC-DC converters. High frequency inductor design and transformer design considerations, magnetic core, current transformers.
Resonant converters: Introduction, Classification: Load resonant, Resonant switch, Resonant DC link, High frequency link integral Half cycle converters: Series and parallel loaded converters in continuous and discontinuous mode of operation, Hybrid resonant DC-DC converter, zero current switch (ZCS), zero voltage switch (ZVS), resonant switch converter, ZCS-clamped voltage converters (ZCS-CV), resonant DC link converters with ZVS.
Control of switched mode DC power supplies: Voltage feed forward PWM control, current mode control, digital pulse width modulation control, isolation techniques of switching regulator systems: soft start in switching power supply designs, current limit circuits, over voltage protection circuit. A typical monolithic PWM control circuit and their application: TL 494. Power factor control in DC-DC converters.
Electromagnetic and radio frequency interference, conducted and radiated noise, EMI suppression, EMI reduction at source, EMI filters, EMI screening, EMI measurements and specifications.
Power conditioners and Uninterruptible Power Supplies, Types of UPS-Redundant and Non Redundant UPS.

Ref. Book:

1. Mohan, Undeland, Robbins-Power Electronics: Converters, Application and Design, John Wiley & Sons, 1989
2. A.I. Pressman –Switching mode power supply design-MGH, 1992
3. M. H. Rashid- Power Electronics, PHI, 2004
4. Michel, D. –DC-DC Switching Regulator Analysis
5. Lee, Y. –Computer Aided Analysis and Design of Switch Mode Power Supply
6. Staff, VPEC. – Power Device & their application

CI 1.2L

Instrumentation Laboratory I

0-0-3 (2 credits)

Full marks: 100 Time: 3 hours

Strain Gauge, LVDT, Thermistor characteristics and linearization, RTD- 3 wire and 4 wire, IC temperature sensor. Capacitive transducer , LDR and photo diodes.
Incremental shaft encoder, Cold junction compensation and linearisation thermocouples; Synchro characteristics. Pressure transducers.

List of Equipment

1. Instrumentation tutor comprising of various sensor modules like thermocouple, RTD, Thermistor, Tachogenerator, Inductive pick-up, Capacitive pick-up, strain Gauge, LVDT, Piezoelectric pick-up, Magnetic pick-up, Photo electric pick up, LDR vibrating beam pick up etc with display and calibrating facilities.
2. Sensor modules with input modulation and output display, Recording facilities: Strain gauge, Thermocouple and other temperature sensors, LVDT, Level, Displacements, Acceleration, Load cells, etc.
3. AD 590, Thermocouples.
4. Shaft encoders
5. Synchros: transmitters, Control transformers, Differential transmitters.
6. Pressure transducer.
7. Variable Power supply, CRO.
8. Photodetectors.

CI 1.1L

Control System Laboratory I

0-0-3 (2 credits)

Full marks: 100 Time: 3 hours

1. Design and simulation of Linearised models using MATLAB/PSPICE.
2. Simulation and analysis of State space models for continuous time and discrete time systems using MATLAB/PSPICE
3. Design and Simulation of LTI models of Feedback Control System using MATLAB/PSPICE.
4. Simulation and analysis of Digital Control System using MATLAB/PSPICE.
5. Simulation and Stability analysis of control system with common non-linearities using MATLAB/PSPICE.
6. Familiarization and use of MATLAB command associated with Robust Control Systems.
7. Familiarization and use of PSIM software.

CI 2.1

Advanced Control Theory

3-1-0 (4 credits)

.

Full marks: 100 Time: 3 hours

Non linear systems

Modelling Quasi-linearisation, stability of non-linear systems, phase plane methods, describing function methods, deriving describing function from FFT, Popov's circle criterion, stability analysis using Lyapunov method, parameter plane analysis.

Modal control, Pole allocation by SV and output feed back.

Order reduction of linear system.

Linear Optimal Control with quadratic performance index Formulation, matrix Riccati equation, special cases, Lyapunovs's equation, LQR problem with prescribed degree of stability (Anderson formulation).

Ref. book : 1. Tan,J.-Modern Control Theory, Mc. Grawhill.
2. Gibson, J.E.- Non linear system , Mc. Grawhill.
3. Alhems M and Falb P.L-Optimal Control, Mc. Grawhill.
4. Anderson and Moore- Optimal Control,PH
5. Bryon and Ho – Applied Optimal Control, John Wiley.
6. Thomson and Stevant- Nonlinear and dynamics and control,Wiley.
7. Vidyasagar- Nonlinear system analysis,PH
8. Atherton,- Nonlinear Control Engineering, Van Nostrand.

CI 2.2

Process Control and Instrumentation

3-1-0 (4 credits)

Full marks: 100 Time: 3 hours

Special Characteristics of process systems: Large time constants, Interaction, Multistaging, Pure Lag; Control loops for simple systems: Dynamics and stability.
Generation of control actions in electronic pneumatic controller.
Tuning of controllers Zeigler Nichols and other techniques. Different control techniques and interaction of process parameters e.g. Feed forward, cascade, ratio, Override controls. Batch and continuous process controls. Multi variable control. Feed forward control schemes.
Control valves, Valve positioners , Relief and safety valves, Relays, Volume boosters, Pneumatic transmitters for process variables.
Various process schemes/ Unit operations and their control schemes e.g. distillation columns , absorbers, Heat exchangers, Furnaces, Reactors, Mineral processing industries pH and blending processes.
Measurement, control and transmission of signals of process parameters like flow, pressure, level and temperature.
Nucleonic instrumentation and its application in industries.
Computer control of processes: Direct Digital Control (DDC), Supervisory Control and advanced control strategies.

Ref Books:

1. Stephananopoulos G- Chemical Process control- An Introduction to theory and practice, PHI, 1990.
2. Luyben W L – Simulation and control for chemical engineers, 1989, 2nd Edition, Mc Graw Hill.
3. Harriot,- Process control, TMH, New Delhi.
4. Patranabis,D.- Principals of Industrial Instrumentation, TMH NewDelhi.
5. Johnson, C – Process Control Instrumentation Technology, PHI New Delhi.
6. Rangan, C.S., Sarma , G.R. and Mani V.S.V, - Instrumentation: Devices and Systems, TMH.
7. Coughanower and Koppel, -Process System Analysis and Control, Mc. Graw Hill.

CI 2.3

Digital Control System

3-1-0 (4 credits)

Full marks: 100 Time: 3 hours

Structure of a computer controlled system.

Review of Z-transform.
Computation of time response of Discrete Data system.
Billnear Transformation.
W-plane, prewarping, inverse transformation.
Design of discrete controllers.
Z-domain compensation, w-plane compensation, state variable feed back
deadbeat controller, sampled data version of PID controllers.
Effect of Data Digitization.
Effect of finite word size, limit cycle determination.
State Variable Analysis of Digital Control Systems.

Ref. books:

1. Gopal, M. – Digital Control Engineering, New Age International. New Delhi.
2. Kuo, B. C. – Digital Control Systems , Oxford University Press.
3. Kuo, B. C. – Analysis and Synthesis of sampled-data control system, PH
4. Houpies, C. H. - Digital Control Systems (Hardware and Software),
5. Philips and Nagle – Digital Control System Analysis and Design.

CI 2.4.1

Adaptive and Robust Control

3-0-0 (3 credits)

.

Full marks: 100 Time: 3 hours

System identification. Problem statement, classical stochastic approach, Kalman filters, structure of on line parameter identifiers.

Adaptive control**.** Need for adaptation, parameter plane analysis, limitation of gain-schedule, structure of self adaptive and auto tuned control systems, stability of adaptive controller.

Multivariable Frequency domain approach for linear systems**.** Characteristics loci, Nyquist arrays, stability criteria, decoupling and compensation.

Robust control**.** Definition and problem statement, the H(n) norm, H$\propto$ norm, frequency domain formulation, state space formulation robust stabilization H_2 optimal control, $H_\propto$ control.

Ref. book:

1. Astrom, - Adaptive Control Techniques, Pearson.
2. Sastry, S. and Bodson,- Adaptive Control (Stabily, Convergence and robustness),
3. Peter Dorato,- Robust Control.
4. Morari and Zafirious, - Robust Process Control,

CI 2.4.2

Soft Computing Techniques

3-0-0 (3 credits)

.

Full marks: 100 Time: 3 hours

Simulation of control systems, frequency domain versus time domain analysis, issues in numerical solution: numerical integration methods, non- linear differential equations, automatic time step control, treatment of switches, Overview of some widely used simulation programs: PSPICE, EMTP, MATLAB/SIMULINK

The mathematics of Fuzzy logic control, Theory of approximate reasoning, Fuzzy knowledge based controllers, application of fuzzy logic control.

Introduction artificial neural networks, Learning in neural networks, Hopfield network, Boltzman machine, Back propagation training algorithm, traveling sales man problem, associative memories, application of Neural network.

Expert system, fuzzy logic and neural networks in control systems: modeling and estimation and design methodologies.

Introduction to Genetic Algorithm.

Ref. book :

1. Klir, G.J. & Yuan,B.- Fuzzy sets and Fuzzy logic, theory and applications, Prentice Hall of India Private Limited
2. Nie and Linkens,- Fuzzy Neural Control-Principles , Algorithms and Application, PHI
3 Bose, B. K.- Power Electronics and variable frequency drives, by, Standard publishers distributor
4 .Kosco, B.-Neural Networks and Fuzzy System.PH
5. Haykin- Neural Network; A Comprehensive Foundation,2/e Pearson .
6. Rajasekaran and Pai – Neural Networks , Fuzzy Logic and Genetic algorithms: Synthesis and Application, PHI.
7. Jackson ,- Introduction To Expert Systems,3/e Pearson.
8. Goldberg,- Genetic Algorithms, Pearson.

CI- 2.4.3

Digital Signal Processing

(3-0-0) 3 Credits

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Full marks: 100 Time: 3 hours

Introduction to signal processing, Review of Laplace transform, Z transform, Fourier transform. Discrete Fourier transform, Fast Fourier Transform, Algorithms and Complexity.
Introduction to linear Optimal Filtering.

Digital Filter :Definition and anatomy of a digtal filter, frecqeency domain description of signals and systems, typical application of digital filters, replacing analog filters with digital filters, filter categories: recursive and non-recursive.

Digital Filter Structures: The direct form I and II structures, Cascade combination of second order sections, Parallel combination of second order sections, Linear- phase FIR filter structures, Frequency sampling structure for the FIR filter.
Effect of word length: Round off error, truncation error, quantization error, limit cycle.

Design of Digital filters

Introduction to DSP hardware

Application of DSP in control system and instrumentation.

Ref Book:

1.Mitra, S. K.- Digital Signal Processing,

2. Proakis J C and Maniolakis D G – Digital Signal Processing : Principles, Algorithms and Applications, PHI.
3. Oppenheim and Shaffer R W - Discrete time Signal Processing - A.V. PHI, 1992.
4. Johnson, J.- Digital Signal Processing , PHI.
5. Venkata Ramani, B. and Bhaskar , M. - Digital Signal Processors. Tata Mc. Graw Hill

CI 2.4.4

Real Time Systems

3-0-0 (3 credits)

Full marks: 100 Time: 3 hours

Overview of Real time systems.

Definition, evolution, typology, structure and applications. Temporal Modelling and specification of real time systems.State diagram, finite automata model, petri-net, state chart and mode chart, Q-model, formal methods.

Sequential and logic control.Ladder diagram, PLC programming, case studies in interlocking and sequence control.

Hardware Components and Configuration of real time system.Interfacing systems for analog and digital I/O, programmable logic control system architecture, computer control system architecture, flight control systems, hardware-in-loop simulation systems, distributed control architecture, reliability enhancement by redundancy.

Real time Operating systems.:Features, primary components.

Structured design of real time systems.Data flow oriented method of analysis and design. Mode chart oriented methods. Development, integration and validation of real time systems. Special consideration for safety critical systems.

Ref Book:

1. Levi and Agarwal, -Real Time System Design,Mc Graw Hill New York,1990
2. A.Burns and A. Wellings,- Real Time Systems and Programming Languages, 2nd ed, Addison Wesley, Reading Mass,1996.
3. Liu,- Real Time Systems, Pearson.
4. Bennett,- Real Time Computer Control: An Introduction, 2/e, Pearson.
5. Meyer,- Real Time Data Handling and Process Control.

CI 2.5.1

Industrial Automation And Control

3-0-0 (3 Credits)

Full marks: 100 Time: 3 hours

Overview: Structure & components Industrial Automation systems. Architectural levels of Industrial controls.

Actuators & sensors: Servomotors, Stepper motors, Process I/O systems. Local & remote I/O systems.

Controllers: Different types of controllers, Single loop and Multiloop controllers and their tunning, Direct controllers and their tunning, Direct controllers and their tunning, Direct controllers and their tunning, Direct controllers and their tunning, Direct controllers and their tunning, Direct controllers and their tunning, Direct Digital Controllers, Software implementation of Multiloop Controllers. Distributed Control Systems.

Sequence Control : Programmable Logic Controllers, Relay Ladder Logic, Programming.
Supervisory Controllers : Functionally of Supervisory Control Level, Process Optimization, Recipe Management Material. Tracking. Man-machine interfaces.

Process Operation Management Systems: Overview of process operation management systems,order ,inventory management,process scheduling,quality management.
Industrial Communication Systems: Characteristic features of industrial networks.Low level networks and their features,Field bus architecture. Performance aspects of Industrial Automation Systems.

Ref. books:
1.Webb J.W-Programmable controllers: Principle and Applications, PHI New Delhi
2. Parr A –Programmable Controllers :An Engineers' Guide ,Newnes, Butterworth-HeinnemanLtd-1993.
3. Liptak B.G (ED)-Process Control H andbook,vol-2 Chilton book Co.
4. Noltinc- Handbook for Instrumentation Engineers.
5. Bollinger J.G and Duffie N.A-Computer control of machines and processes,Reading M A ,Addison-Wesley.,1988.

2.5.2

Data Communication

3-0-0 (3 Credits)

.

Full marks: 100 Time: 3 hours

Modulation techniques, Different kinds of AM and FM. AM and FM modulators and demodulators. Sensitivity for wire and wireless transmission. Power line carrier communication. Sampling theorem, Nyquist frequency, sampling techniques and signal reconstruction. Pulse code modulation, PAM, PWM, PPM signals.Pulse code modulation. Coding formats. Digital data communication techniques. Multiplexing, FDM and TDM systems, their relative merits, ASK, FSK,PSK and higher order modulation, techniques. Local area and public data Networks.

Data transfer techniques- asynchronous and synchronous. Serial and parallel interface Standards. Communication media and adapters. Modems and their interfacing. IRIG and CCITT standards. Fiber optic and satellite communication. Remote control, Mechanical, electrical and electronic methods, special considerations. Typical telemetry and telecontrol schemes related to industry and space application.

Ref.Book:

1. Carlson B.A- Communication Systems- An Introduction to signals and Noise in Electrical Communiction, McGraw Hill International Students' Edition, 1986.

2. Schwartz M- Information transmission, modulation and noise, McGraw Hill, 1970.
3. Tanenbaum A,- Telecommunication Network, Pearson.
4. Proakis,J.G- Digital Communication , Mc. Grawhill
5. Miller,- Data Network Communication, Vikas.

CI 2.5.3

Experimental Methods and Analysis

3-0-0 (3credits)

Full marks: 100 Time: 3 hours

Errors of measurement, Classification of errors, Systemic and random errors: Statistical analysis of errors, Normalized histograms, Probability distribution functions; Gaussian error curves, Chi-squared statistical

test, Regression analysis of data, Best fit curve and estimation of model; Combination of errors, Variance of sum of two sets, Errors of computed results – examples from engineering measurements, Special functional forms; Methods of measurements – Classification and examples; Instrument scales and reading errors; Methods of minimization and elimination of errors due to noise in measured data – Input-output configuration, filtering, averaging and correlation techniques; Errors in digital instruments.

Ref. Books

1. Holman J P – Experimental Methods for Engineers, Mc Graw Hill Book Co., International Student Edition, 1966.
2. Cook N H and Robinowicz E – Physical Measurements and Analysis, Addison Wesley, 1965.
3. Schenk – Engineering Experimentation, McGraw Hill.

CI 2.5.4

Ultrasonic Instrumentation

3-0-0 (3 credits)

.

Full marks: 100 Time: 3 hours

Ultrasonic waves, principles and propagation of various waves. Characterization of Ultrasonic transmission – reflection and transmission coefficients, intensity and attenuation of sound beam. Power level, medium parameters, Generation of Ultrasonic waves – Magnetostrictive and Piezoelectric effects. Search unit – types, construction, characteristics. Ultrasonic test methods – pulse echo, transit time, resonance, direct contact and immersion type, Ultrasonic mrthods of flaw detection. Ultrasonic method of measuring thickness, depth, flow etc. Variables affecting ultrasonic testing in various applications, Ultrasonic applications in Medical Diagnosis and Therapy, Acoustical holography.

Ref. Books

1. Krauthsamer J and Krauthsamer H – Ultrasonic Testing of Materials, Springer Verlag, Berlin, New York.
2. Wells N T – Biomedical ultrasonic, Academic Press, London, 1977.

CI 2.1L

Control System laboratory II

0-0-3 (2 credits)

Full marks: 100 Time: 3 hours

Designing of Ladder logic for various practical applications, Execution of the Ladders using PLC's.
Study of Analog and Digital Servo Systems.
Experiments on Position Control System, Velocity Control System, Adaptive Control System and Non-Linear Control Systems.

CI 2.2L

Instrumentation laboratory II

0-0-3 (2 credits)

Full marks: 100 Time: 3 hours

Calibration of Bourdon Gauge using dead weight tester; Determination of discharge coefficient using Orifice Meter; Calibration of Rotameter; Determination of time constants of a Thermocouple; Study and calibration of Differential pressure transmitter; Speed measurement using non-contact type sensor; Measurement of very small angles and displacements , Level measurements using air purging, pH meter, Conductivity meter.

Note 1: Typical experiments on chemical processes may comprise of –

1. Measurement of velocity distribution fro a fluid flowing through a cylindrical tube by a Pilot tube.
2. To find equivalent length of different pipe fittings.
3. To determine the surface area and also the shape factor of particles by permeability method.
4. To study the characteristics of fluid flow through a packed bed.
5. To study the working of different crushers and ball mills.
6. Heat transfer studies in counter current and co-current double pipe heat exchangers.
7. To determine the thermal conditions of different solids.
8. Mass transfer studies in bubble cap/sieve plate /packed bed distillation column using binary mixtures.
9. To study the characteristics of batch, plug flow and mixed reactor using homogeneous reactions.
10. RTD study for fluid through a tubular reactor.

Note 2: Students will perform 8-10 experiments on processes and process instrumentation(combined)

List of Equipment:

1. pH meter setup (electrodes, electrometer set up).
2. Conductivity meter set up.
3. Models of Heat Exchanger, distillation column, Tubular reactor, Mixed reactor along with accessories.
4. Instrumentation tutor for Flow meter calibration.
5. Pilot tube.
6. Function generator, Dual trace CRO, Storage CRO, Audio cassette recorder, Multimeters, Analog/ Digital voltmeters, etc.
7. Water level controller.

CI 3.1.1

Remote Sensing and Control

3-0-0 (3 credits)

Full marks: 100 Time: 3 hours

Nature of electromagnetic radiation - spectral, spatial and temporal characteristics of objects - atmospheric interaction sensors - photographic, thermal, multi-spectral, passive microwave and active microwave sensors - ground data acquisition - photo-interpretation - image processing techniques, remote sensing applications.
Techniques of remote control; remote control in Industry including Oil pipelines, rocket motion and satellite movements.

Ref Book:

1. Barett, E.C. and Curtis, L.F.- Introduction To Environmental Remote Sensing, 3/e, Chapman Hall, New York 1992.
2. Campbell, J.B.- Introduction to Remote Sensing , Guilford, New York 1987.
3. Lo, C.P. – Applied Remote Sensing, Wiley, New York 1986.

4. Swain, P.H. and Davis,S.M. (eds) – Remote Sensing ;The Quantitative Approach, Mc. Graw Hill New York 1978.

CI 3.1.2

Robotics

3-0-0 (3 credits)

Full marks: 100 Time: 3 hours

Basic concepts : Definition and origin of robotics – different types of robots – various generations of robots – degrees of freedom – Asimov's laws of robotics – Dynamic stabilization of robots.
Power sources and sensors : Hydraulic, pneumatic and electric drives – Determination of HP of motor and gearing ratio – variable speed arrangements – path determination – machine vision – ranging – laser-acoustic – magnetic – fibre optic and tactile sensors.
Manipulators, Actuators and Grippers : Construction of manipulators – manipulator dynamic and force control – electronic and pneumatic manipulator control circuits – and effectors – various types of grippers – design considerations.

Ref. Book:

1. Mair, G.M. –Industrial Robotics, Prentice Hall, NY, 1988.
2. Khafter, R.D., Chimelewski, T.A. and Negin, M. – Robot Engineering – An Integrated Approach, PHI, New Delhi, 1994.
3. Braddley, M. et. Al. (Eds) – Robot Motion: Planning and Control, MIT Press, Cambridge, Mass, 1982.
4. Lee, C.S.G. – Robot Arm Kinematics, Dynamics and Control, Computer, IEEE, Vol. 15, No. 12.
5. Paul, R.P. – Robot Manipulators: Mathematics, Programming and Control, MIT Press, Cambridge, Mass, 1981.
6. Mittal and Nagrath,- Robotics and Control, Tata Mc. Graw Hill,.
7. Sponge, M., and Vidyasagar M- Robot Dynamics and Control, John Wiley New York 1989.
8. Craig J.J.- Introduction to Robotics; Mechanisms and Control, 2/e, Addison Wesley, Reading, Mass 1989.

CI 3.1.3

Reliability and Safety Engineering

3-0-0 (3 credits)

Full marks: 100 Time: 3 hours

Reliability: Definition and basic concepts, Failure data, failure modes and reliability in terms of hazard rates and failure density function. Hazard models and bath tub curves. Applicability of Weibull distribution. Reliability calculation for series , parallel, parallel-series and K-out-M systems. Use of redundancy and system reliability improvement methods.
Maintenance: Objectives, Types of maintenance, preventive, condition based and reliability centered maintenance. Terotechnology and total productive maintenance.(TPM).
Maintainability: Definition, basic concepts, Relationship between reliability, maintainability and availability : corrective maintenance time distributions and maintainability demonstration. Design considerations for maintainability. Introduction to life-testing-estimation of parameters for exponential and Weibell distributions, component reliability and MIL standards.
Safety: Causes of failure and unreliability. Human reliability and operator training. Origins of consumerism and importance of product knowledge, product safety, product liability and product safety improvement programme.

Ref. Books:

1. Charls O. Smith, - Introduction to Reliability In Design, Mc. Graw Hill.
2. Blanchard B.S – Maintainability
3. Sinha And Kale – Introduction to Life Testing, Willey Eastern
4. Smith and Davis – Reliability Engineering.
5. Gloss, D.S. and Wardle, M.G- Introduction to Safety Engineering , John Wiley.and sons, New York.
6. Brown, D.B.- Systems Analysis and Design Of Safety, PHI, New Delhi
7. Billinton, R and Allan, R- Reliability Evaluation of Engineering Systems, Pitman Books Limited, London.

CI 3.1.4

Artificial Intelligence

3-0-0 (3 credits)

.

Full marks: 100 Time: 3 hours

Basic problem solving methods : Production systems – State space search – Control strategies – Heuristic search – Forward and backward reasoning – Hill Climbing techniques – Breadth first search – Depth first search – Best search – Staged search.

Knowledge representation : Predicate logic – Resolution Question answering – Nonmonotic reasoning – Statistical and probabilistic reasoning – Semantic Nets – Cenceptual dependency – Frames – Scripts.

Al Languages : Important characteristics of Al languages – PROLOG.

Introduction to expert system – interaction with an expert. Design of an expert system.

Neural Networks : Basic structure of a neuron Perception Feedforward, Back propagation, Hopfield Network.

Ref. Books

1. Rich E and Knight K – Artificial Intelligence, Tata McGraw Hill, New Delhi, 1991.
2. Nilsson N J – Principals of Artificial Intelligence, Springer Verlag, Berlin, 1980.
3. Barr A, Fergenbaum E A and Cohen P R – Artificial Intelligence, Addison-Wesley, Reading (Mass), 1989.
4. Waterman DA – A Guide to Expert System, Addison-Wesley, Reading (Mass), 1986.
5. Artificial Intelligence Handbook, Vol 1-2, ISA, Research Triangle Park, 1989.
6. Kos Ko B – Neural Networks and Fuzzy System, PHI.
7. Russel – Artificial Intelligence, Pearson.
8. Luger- Artificial Intelligence, 4/e Pearson.
9. Patterson- Introduction to Artificial Intelligence and Expert Systems, PHI.

CI 3.2.1

Optical and Laser Instrumentation

3-0-0 (3 credits)

.

Full marks: 100 Time: 3 hours

Characteristics of light sources. Coherence. Instruments – Microscopic , binocular, stereoscopic, polarization and phase contrast microscopes, photographic systems. Telephoto lens, zoom lens and shutters.

Interferometry : Interference of light Newton's Interferoscope, Fizeau Interferometer. Twyman Green Interferometer, Mach-Zehnder Interferometer.
Laser Instrumentation : Gas lasers, solid-state lasers, liquid lasers, semiconductor lasers. Laser Modes – Q switching-frequency doubling.
Laser Applications : Distance Measurement, Laser-Doppler Velocimetry, Welding, Cutting, Machining, Holography, Holographic Interferometry.

Ref. Books

1. Rampal V V – Lasers and Applications.
2. Smith W V and Sorokin P P – The laser, Mc Graw Hill Book Co., 1996.
3. Culshaw B and Dakin J (ED) – Optical Fiber Sensors, Vol. 1, 2, Artech House, 1989.
4. Ghatak AK – Optics, TMH Book Co.

CI 3.2.2

Biomedical Instrumentation

3-0-0 (3 Credits)

Full marks: 100 Time: 3 hours

Introduction to the physiology of cardiac, nervous and muscular and respiratory systems.

Transducers and Electrodes : Different types of transducers and their selection for Biomedical applications, Electrode theory, Different types of electrode Hydrogen Calomel, Ag-Agcl, Ph, P_{o2} P_{co2} electrodes, selection criteria of electrodes.

Cardiovascular measurement: The heart and other cardio vascular systems, Measurement of Blood pressure, Blood flow, Cardiac output and cardiac rate, Electrocardiography, Phonocardio-graphy, Ballistocardiography, Plethysmography, Magnet-Cardiography, Cardiac pace-maker, Computer applications.

Measurement of electrical Activities in Muscles and Brain: Electromyography, Electroencephalograph and their interpretation. Respiratory system measurement: Respiratory mechanism, Measurement of gas volume , flow rate carbon dioxide & oxygen concentration in inhaled air, Respiratory controller. Instrumentation for clinical laboratory: Measurement of pH value of blood. ESR Measurement, Haemoglobin Measurement , oxygen & carbon dioxide concentration in blood, GSR Measurement, Polarographic Measurement, computer application.

Medical Imaging: Ultra sound Imaging, Radiography, MRI, Electrical tomography & applications.
Biotelemetry : Transmission and reception aspects of biological signals via long distances.

Aspects of patient care monitoring

Ref. Books:

1. Webster J S –Medical instrumentation-Application & Design.
2. Cromwell L Biomedical instrumentation, PHI
3. Khandpur R S Hand book on Biomedical instrumentation,TMH,N.Delhi1991.
4. Astor B R introduction to Biomedical instrumentation & measurement, McMillan.

3.2.3

Image Processing

3-0-0 (3 Credits)

Full marks: 100 Time: 3 hours

Underlying principles of image formation and enhancement; Techniques &mechanisms of image capture & display; Low level segmentation; feature detection of 2-D & 3-D images; Dynamic scene analysis; Colour image analysis and occluded scene analysis.

Ref. Books:

1. Jain, A K- Fundamentals of digital image processing, PHI.
2. Gongalez, R C and Wintz, P- digital image processing ,2/e Addison Wesley,1987.
3. Rosenfield, A and Kak, A C - digital image processing, vol-1 vol-2 ,Academic press ,1982.
4. Gonzalez, R.C. and Woods, R.E. – Digital Image Processing, Pearson.
5. Dutta Majumdar, D and Chanda, B- Digital Image Processing and Analysis, PHI, New Delhi , 2000.

CI 3.2.4

Analytical Instrumentation

3-0-0 (3 credits)

.

Full marks: 100 Time: 3 hours

Introduction- Difference between analytical and other instruments. Online instrumentation and laboratory techniques. Sampling techniques for liquids and gasses analysis purpose. Gas analysis: Gas chromatography , Thermal conductivity method, Heat of reaction method, Estimation of oxygen, Hydrogen, Methane, Carbon Dioxide, Carbon Monoxide, etc. in binary or complex gas mixtures. Zirconia - probe oxygen analyzers, paramagnetic oxygen meters. Electrochemical reaction method. Humidity and moisture measurements technique. Chemical composition analysis: Measurement of viscosity, Turbidity meter consistency. PH and redox potential, Electrical conductivity. Techniques of density measurements: Solids, Liquids and gases. Spectrochemical analysis: Mass spectrometer, Emission spectrometer, Absorption spectrometry. Dispersive and non dispersive techniques.

Ref. Books:

1. Patranabis D- Principles of Industrial Instrumentation, TMH publication, New Delhi, 1976.
2. Liptak B G(Ed) – Instrument Engineers Handbook, Volume I and II and supplement I and II, Chilton book co., Philadelphia, 1972.
3. Jones E B- Instrument technology, Volume II, Analysis instruments, Butterworth Scientific Publication , London.
4. O'Higgins P J - basic Instrumentation in industrial measurements, McGraw Hill Book co, NY 1966.
5. Skoog D A and West D M- Principles of Instrumental Analysis.
6. Merritt W H W , Dean L L and Settie J A – Instrumental Methods of analysis.
7. Ewing G W – Instrumental Methods of Chemical Analysis, 5th Edition, Mc Graw Hill, NY 1985.