Course Structure & Curriculum

For

M. Tech. Programme

In

Electrical Engineering

With Specialization in

Control & Instrumentation

(Effective from Session 2017-18)

Department of Electrical Engineering
Motilal Nehru National Institute of Technology Allahabad
Teliarganj, Allahabad-211004, Uttar Pradesh

MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY ALLAHABAD

VISION

To establish a unique identity for the institute amongst national and international academic and research organizations through knowledge creation, acquisition and dissemination for the benefit of society and humanity.

MISSION

- To generate high quality human and knowledge resources in our core areas of competence and emerging areas to make valuable contribution in technology for social and economic development of the nation. Focused efforts to be undertaken for identification, monitoring and control of objective attributes of quality and for continuous enhancement of academic processes, infrastructure and ambience.
- To efficaciously enhance and expand, even beyond national boundaries, its contribution to the betterment of technical education and offer international programmes of teaching, consultancy and research.

DEPARTMENT OF ELECTRICAL ENGINEERING

VISION

To produce globally competitive technical manpower with sound knowledge of theory and practice, with a commitment to serve the society and to foster cutting edge research in Electrical Engineering pertaining to the problems currently faced by the country and the world.

MISSION

1. Develop state of art lab facilities for research and consultancy
2. Develop infrastructure and procure-cutting edge tools/equipment
3. Develop relevant content and capability for quality teaching
4. Improve symbiotic relationship with Industry for collaborative research and resource generation.

<u>**M.Tech (Electrical Engineering) with specialization in Control & Instrumentation**</u>

Course Structure & Scheme of Evaluation (Effective from Session 2017-18)

I Semester

Subject code	Subject Name	L	T	P	Credits				Total Marks
						TA	MSE	ESE	
EE 21101	Linear System Theory	3	1	0	4	20	20	60	**100**
EE 21102	Digital Control	3	1	0	4	20	20	60	**100**
EE 213xx	Elective I	3	1	0	4	20	20	60	**100**
EE 213xx	Elective II	3	1	0	4	20	20	60	**100**
EE 213xx	Elective III	0	0	6	4	50	0	50	**100**

Total Credits= 20

II Semester

Subject code	Subject Name	L	T	P	Credits				Total Marks
						TA	MSE	ESE	
EE 22101	Industrial Instrumentation	3	1	0	4	20	20	60	**100**
EE 22102	Nonlinear Control	3	1	0	4	20	20	60	**100**
EE 223xx	Elective IV	3	1	0	4	20	20	60	**100**
EE 223xx	Elective V	3	1	0	4	20	20	60	**100**
EE 223xx	Elective VI	0	0	6	4	50	0	50	**100**

Total Credits= 20

III Semester

Subject Code	Subject Name	Credits	Eval (100)
EE 23651	State of art Seminar	4	Marks
EE 23601	Thesis	16	Marks

IV Semester

Subject Code	Subject Name	Credits	Eval (100)
EE 24601	Thesis	20	Marks

Note-1: The distribution of thesis evaluation marks will be as follows:

1. Supervisor(s) evaluation component 60%
2. Oral Board evaluation component 40%

11.10.17

Vector spaces, linear subspaces, eigen-value and eigenvectors, matrix inversion formulae, invariant subspaces, vector norms and matrix norms, Singular value decomposition(SVD), semi-definite matrices, singular values, H_2, H_∞ and L_p, spaces and norms for transfer matrices, small gain theorem.

Basic principle of linear time variant/ linear time invariant systems, Impulse Response, Transfer function, Solution to homogeneous/non-homogeneous linear systems, similarity transformations, canonical forms, state space realization of transfer matrices, controllability and observability, pole placement and observer based controllers, Minimal realization.

Lyapunov stability, Stability of locally linearized systems, BIBO stability, BIBO versus Lyapunov stability.

References:

1. Chin-Tsong Chen, "Linear system theory and design," Oxford Univ Pr (Sd), 4 edition, 2012.
2. T. Kailath, "Linear system theory," Prentice-Hall, Inc.,1st edition, 1980.
3. M. Gopal, "Modern control system theory," New Age International, 1993.
4. K. Ogata, "System dynamics," Prentice Hall, 4 edition, 2003.
5. Ben Noble, "Applied linear algebra," Pearson, 3 edition, 1987.
6. Ashish Tewari, "Modern Control Design with MATLAB and SIMULINK," John Wiley & Sons, Ltd, 2012.
7. M. H. Rashid, "Power electronics handbook," Elsevier Publication, 2001.
8. Jason L. Speyer and Walter H. Chung, "Stochastic Processes: Estimation and Control," Publisher: SIAM (Society for Industrial and Applied Mathematics) 2013.

11.10.17

Introduction and historical development of computer controlled systems, components of digital control, sample & hold, Z-transform, difference equations and realization of Z-transform function, translation of Analog design-approximations, Jury's stability, closed loop transfer function of sampled data-control systems, state-space representation of computer-controlled systems, Digital PID, Lyapunov-stability analysis, pole placement and observer design, dead-beat control, Control using microcomputer, microprocessor, micro-controller and DSP-based control system, programming technique for real time control.

References:

1. M. Gopal, "Digital control and state variable methods," McGraw Hill Education (India) Private Limited 3 edition, 2008.
2. G.H. Hostetter, "Digital control system design," Oxford Univ Pr (Sd), 1987.
3. Stuart Bennette, "Real time computer control," Prentice Hall PTR, 2 edition, 1994.
4. W. Forsythe and R.M. Goodall, "Digital control," Mcgraw-Hill, 1991.
5. Katz, Paul, "Digital Control using microprocessor," Prentice Hall International, First Edition edition 1981.
6. Astrom and Wittennark, "Computer controlled systems: Theory and Design," Prentice Hall, 3 edition, 1996.
7. K. Ogata, "Discrete time control systems," Prentice Hall, 2 edition, 1995.
8. B. C. Kuo, "Digital control systems," Oxford University Press, 2 edition, 1995.

11.10.19

EE 22101 Industrial Instrumentation **SECOND SEMESTER**

Review of transducers for strain, velocity, acceleration, vibration, pressure, level, force, flow, temperature, etc., Optic & LASER Instrumentation; Smart instrumentation Signal conditioning Design - Specification, error considerations; Selection & design of typical subsystems; Instrumentation amplifiers, logarithmic amplifiers, isolation amplifiers, sample and hold, active filters, etc. ; Data converters ADCs & DACs; Design of data instrumentation systems, Networking methods and their applications in instrumentation; Industrial standards; Electrical hazards and safety, Wireless technology, Smart sensor & actuators.

References:

1. E.O. Doebelin, "Measurement Systems – Application and Design," Tata McGraw Hill, 6th edition 2012.
2. D. Patranabis, "Principles of Industrial Instrumentation," Tata McGraw Hill, 3rd edition 2010.
3. S. K. Singh, "Industrial Instrumentation and Control," Tata McGraw Hill, 3rd edition 2008.
4. D.P. Eckman, "Industrial Instrumentation," Wiley Eastern Ltd , 1st edition, 2004.
5. A.S.Morris, R.Lengari, "Measurement and Instrumentation-Theory & Application," Academic Press; 2nd edition 2015.
6. Ronald L. Krutz, "Interfacing techniques in digital design with emphasis on Microprocessors," Wiley, 1988, ISBN-0471082899, 9780471082897.
7. David F. Hoeschele, "Analog to digital and digital to analog conversion techniques," Wiley- Inter science, 2nd edition, 1994.
8. John Park, Steve Mackay, E. Wright, "Data Communication for Instrumentation and Control," Newnes; 1 edition August 11, 2003.

EE 22102 Nonlinear Control SECOND SEMESTER

Introduction to nonlinear systems; Linearization; Comparison of linear and nonlinear systems; Fundamentals of describing function method: describing function analysis of nonlinearities such as saturation, dead-zone, on-off non-linearity, backlash, hysteresis; Analysis of nonlinear systems using phase plane technique, limit cycles; Stability analysis of nonlinear systems: Lyapunov stability theorem for Nonlinear system; Variable Structure Control; Sliding Mode Control; Higher Order Sliding; Feedback linearization: input-state linearization, input-output linearization; back stepping control

References:

1. M. Vidyasagar, "Nonlinear system analysis," Society for Industrial and Applied Mathematics, Second Edition, 2002.
2. D. Graham, "Analysis of nonlinear control systems," Wiley, New York, 1985.
3. N. Minorsky, "Theory of nonlinear control systems," McGraw-Hill, New York, 1969.
4. H. K. Khalil, "Nonlinear systems," Prentice Hall, Third Edition, 2001.
5. J. J. E. Slotine, "Applied nonlinear control," Prentice-Hall, 1991.

11·10·13

List of Electives for Control & Instrumentation

List of Subjects in Elective I

1. EE 21301 Optimization Techniques
2. EE 21302 Expert Systems
3. EE 21303 Neuro-Fuzzy Control Systems
4. EE21304 Digital Signal Processing

List of Subjects in Elective II

1. EE 21311 Biomedical Instrumentation
2. EE 21312 Smart Sensors & Actuators
3. EE 21313 Process Control & Instrumentation
4. EE 21314 Virtual Instrumentation

List of Subjects in Elective III

1. EE 21321 Advanced Control Lab
2. EE 21322 Mini Project

List of Subjects in Elective IV

1. EE 22301 Robot Modeling and Control
2. EE 22302 Robust Control Systems
3. EE 22303 Digital System Simulation
4. EE 22304 Optimal Control

List of Subjects in Elective V

1. EE 22311 Special topics in Control Systems
2. EE 22312 Introduction to Probability Theory & Stochastic Process
3. EE 22313 System Identification &Estimation
4. EE 22314 Adaptive Control

List of Subjects in Elective VI

1. EE 22321 Instrumentation Lab
2. EE 22322 Mini Project

11.1017

Classical optimization techniques: Single variable optimization, multivariable optimisation with constraints and without constraints, necessary and sufficient conditions.

Linear programming (LP): Two variable problems-graphical solutions, formulation of LP problems in more than two variables, standard form, Simplex algorithm, special cases-2 phase's method, Big-M method, duality and dual LP problems. Application of LP in Transportation problem-balanced and unbalanced transportation problems. Use of North West corner rule, least cost method, Vogel approximation method. Assignment problems- Hungarian method.

Non-linear programming (NLP): Philosophy of numerical methods, search methods for one dimensional problems- Fibonacci and Golden section methods. Unconstrained and constrained optimization, univariate method , Pattern search method , Steepest descent method, cutting plane method , penalty function method, basic idea of dynamic programming.

Evolutionary algorithms (EA): Genetic algorithm, particle swarm optimisation, Tabu search, simulated annealing and ant colony optimization, Multi objective optimization using EA, Pareto solutions.

Reference:

1. S.S. Rao, *Engineering Optimization: Theory and Practice*. New York: Wiley. 2009.
2. K. Deb, *Multiobjective Optimization using Evolutionary Algorithms*. New York; Wiley. 2002.
3. G.P. Liu, J.B. Yang and J.F. Whidborne, *Multiobjective Optimization and Control*. PHI. 2008.
4. A. D. Belegundu, and T. R. Chandrupatla, *Optimization Concepts and Applications in Engineering*, Pearson Education (Singapore). 2003.
5. R. L. Rardin, *Optimization in Operation Research*. Prentice-Hall. 1999.
6. A. Schirisieer, *Theory of linear and integer programming*, John Wiley and Sons, 1986.
7. D. Leunberger, *Linear and Nonlinear programming*, Add. Wesley, 1984.

11-10-12

EE 21302 Expert Systems **FIRST SEMESTER (E-I)**

Introduction, Expertise and Heuristic knowledge, knowledge based systems, Structure of knowledge based systems, Logic and automated reasoning, Predicate logic, logical inference, Resolution, Truth maintenance systems, Rule based reasoning, Forward chaining , Backward chaining, Rule based architectures, conflict resolution schemes, Associative networks, Frames and Objects, uncertainty management, Baynesian approaches, Certainty factors, Dempeter-Shefer theory of Evidence, Fuzzy sets and Fuzzy logic, knowledge Acquisition search strategies and matching techniques.

References:

1. Peter Jackson, "Introduction to expert systems," Addison-Wesley, 3 edition, 1998.
2. Archino J. Gonzalez Douglas D. Dankel and Douglas D. Dankel II, "The Engineering of knowledge based systems," Prentice Hall, 1993.
3. Dan W. Patterson, "An introduction to artificial intelligence and expert systems," Prentice Hall, 1990.
4. Sasikumar et al., "Rule based expert systems," Narosa Publishing, 1996.
5. Janusz S. Kowalik, "Knowledge based problem solving," Prentice Hall, 1986.
6. Frederick Hayes-Roth, Donald A. Waterman and Douglas B. Lenat, "Building expert systems," Addison-Wesley Longman Publishing Co., Inc. Boston, MA, USA, 1983.

EE 21303 Neuro-Fuzzy Control Systems **FIRST SEMESTER (E-I)**

Introduction, neuron model, activation functions, perceptions, multilayer network, Back propagation, re-current networks, supervised and unsupervised learning, principle component analysis, modeling, identification, prediction and control using neural network controllers, Basics of sets and fuzzy arithmetic, crisp sets, operation, relation and composition of sets, Fuzzification and defuzzification methods, Fuzzy logic, software and hardware application to closed loop control, TSK Fuzzy Models, Fuzzy controllers.

References:

1. Simon Haykin, "Neural networks - A comprehensive foundation," Prentice Hall, 2003.
2. M. T. Hagan , "Neural network design , Cengage Learning," 2nd edition, 2008
3. D. T. Pham and X Liu, "Neural network for identification, prediction and control," Springer , 1995
4. Klir George J., Yuan Bo, "Fuzzy Sets and Fuzzy Logic: Theory and Applications," Prentice-Hall (1996)
5. B. Kosko, "Neural Networks and Fuzzy Systems," Prentice-Hall, 1994
6. T. J. Ross , "Fuzzy Logic with Engineering Applications Wiley-Blackwell;" 3rd edition 2010.

1.10.12

DFT- Walsh- Hadamard transforms, discrete convolution and correlation, FFT algorithms, Digital filters-flow graph and Matrix representation, IIR and FIR filter design, Signal processing algorithm, waveform generation, Quadrature signal processing, Signal detection , modulation techniques, frequency translation, over ranging, Issues involved in DSP processor design-speed, cost, accuracy, pipelining, parallelism, quantization error, etc., Key DSP hardware elements - Multiplier, ALU, Shifter, Address Generator, etc., Software development tools-assembler, linker and simulator, Applications using DSP Processor - spectral analysis.

References:

1. A.V. Oppenheim and R. W. Schfar, "Digital signal processing," (Englewood Cliffs, N. J., Prentice-Hall, 1975.
2. A.Bateman and W. Yates, "Digital signal processing design," W H Freeman & Co (Sd), 1989.
3. A. Antoniou, "Digital filters analysis and design," McGraw-Hill Science / Engineering / Math, 2nd edition. 2000.

Introduction to Biomedical Instrumentation; Basic concepts of Medical Instrumentation: Generalized medical Instrumentation System, Medical Measurement constraints, classification of Biomedical Instruments.

Anatomy and Physiology, Biomedical electrode sensors and transducers; Various types of electrodes used in ECG, EEG and EMG, Measurement of EEG, EMG and their diagnostic applications in Medicine, Flow and pressure measuring instruments in biomedical engineering,

Instrumentation in Diagnostic Cardiology: Pacemakers and Defibrillators; EEG and EMG Instrumentation; Instrumentation in Respiration; Artifacts and noise medical instrumentation.

Instrumentation in Diagnostic Ultrasound, Instrumentation in medical imaging, Fibre optics and LASER in biomedical instrumentation.

Instrumentation in Intensive Care Units, Instrumentation in operating room.

Biomedical safety Instrumentation: Medical safety, Regulation and Standards, Preventive maintenance. Computers and Telemedicine, New technologies and advances in medical instrumentation

References:

1. Cormwell L. et al., "Bio medical Instrumentation & Measurements," PHI 2 edition, 1990.
2. Khandpur R.S., "Hand book of biomedical instrumentation," Tata Mc graw-Hill, 1992.
3. Shakti Chatterjee, Aubert Miller, "Biomedical Instrumentation Systems," Cengage Learning. Cengage Learning, 1 edition, 2010.
4. R. Anandanatarjan, "Biomedical Instrumentation and Measurements," PHI, 2011.
5. Carr & Brown, "Introduction to Biomedical Equipment," Prentice Hall, 4 edition, 2000.
6. Webster JG, "Medical Instrumentation: Application and Design," 4th ed., John Wiley & Sons, New York, 2009.

11-10-17

Performance specification and analysis of sensors: analog and digital motion sensors, optical sensors, temperature sensors, magnetic and electromagnetic sensors, acoustic sensors, chemical sensors, radiation sensors, torque, force and tactile sensors etc.

The current technology of sensors: electronic, photonic, micro fluidics and new materials. Integration of electronics with sensors.

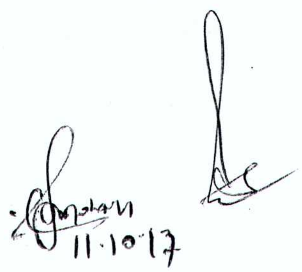
Actuators: stepper motors, DC and AC motors, hydraulic actuators, magnet and electromagnetic actuators, acoustic actuators.

Introduction to interfacing methods: bridge circuits, A/D and D/A converters, microcontrollers.

Sensor Network Architecture and Applications: Introduction, Functional Architecture for Sensor Networks, Sample Implementation Architectures, Classification of WSNs, Characteristics, Technical Challenges, and Design Directions, Technical Approaches, Coverage in Wireless Sensor Networks, Location in Wireless Sensor Networks, Data Gathering and Processing.

References:

1. Ida, N.; Sensors, Actuators, and their Interfaces;2014; Scitech Publishing.
2. Handbook of Modern Sensors, 2nd Ed. By Jacob Fraden.
3. Semiconductor Sensors, Edited by S. M. Sze.
4. Wireless Sensor Networks: F. Zhao, C. Guibas, Elsevier, Morgan Kaufmann, 2004.



EE 21313 Process Control and Instrumentation **FIRST SEMESTER (E-II)**

Introduction to Process Control, Mathematical Modeling: Development of mathematical models, Modeling considerations for control purposes. Dynamic Behaviour of Chemical Processes: Computer simulation and the linearization of nonlinear systems, Transfer functions and the input-output models, Dynamics and analysis of first, second and higher order systems. Feedback Control Schemes: Concept of feedback control, Dynamics and analysis of feedback-controlled processes, Stability analysis, Controller design, Frequency response analysis and its applications Advanced Control Schemes: Feedback control

of systems with dead time or inverse response, Control systems with multiple loops, Feed forward and ratio control. Instrumentation: Final control elements, Measuring devices for flow, temperature, pressure and level.

References:

1. Harriot, P. " Process control," Tata McGraw-Hill Education, 1964.
2. Singh, S.K. "Computer Aided process control," PHI Learning Pvt. Ltd., 2004.
3. Seborg,Edgar, Mellichamp, "Process dynamics and control," John Wiley & Sons, Inc., 2 Edition, 2000.
4. Marlin,T.E. "Process control –:Designing processes & control systems," McGraw-Hill Higher Education; 2 edition, 2000.
5. Bennet, S. "Real time computer control," Pearson India, 2 Edition, 2003.

11.10.17

EE 21314 Virtual Instrumentation **FIRST SEMESTER (E-II)**

Introduction, Virtual instrumentation (VI) advantages, Graphical programming techniques, Data flow programming, VI's and sub VI's, Structures, Arrays and Clusters, Data acquisition methods, File I/O, DAQ hardware, PC hardware: operating systems, Instrumentation buses, ISA, PCI, USB, PXI, Instrument control, Data communication standards, RS-232C, GPIB, Real time operating systems, Reconfigurable I/O, FPGA.

References:

1. Jovitha Jerome, *Virtual Instrumentation Using Lab VIEW*, PHI Learning Pvt. Ltd, New Delhi, 2009.
2. S. Gupta and J. John, *Virtual Instrumentation Using Lab VIEW, Tata McGraw-Hill,* New Delhi, 2005.
3. R.H. Bishop, *Lab VIEW 7 Express Student Edition,* Prentice Hall, 2003.
4. National Instruments, *Lab VIEW User Manual, USA, 2003.*
5. National Instruments, *Lab VIEW Real Time User Manual, USA, 2001.*
6. National Instruments, *Lab VIEW FPGA Module User Manual, USA, 2004.*
7. L. Sokoloff, *Application Lab VIEW,* Prentice Hall, USA, 2003.
8. N. Ertugrul, *Lab VIEW for Electrical Circuits, Machine Drives and Labs,* Prentice Hall Professional, USA, 2002.
9. J. Essick, *Advanced Lab VIEW Labs,* Addison Wesley; 1 Edition, USA, 1998.
10. G.W. Johnsons, *Lab VIEW Graphical Programming,* McGraw-Hill Professional; 4 Edition, 2006.

Part A: Simulation based Experiments

1. Introduction of Matlab Software and basic mathematical operations in Matlab.
2. To obtain the time response (step, impulse and ramp response) and the transfer function of the continuous and discrete time systems using Matlab.
3. To study the time domain performance indices (rise time, settling time, delay time, maximum peak overshoot etc.) of the continuous and discrete time systems using Matlab.
4. To study the stability of continuous and discrete time systems using root locus, Nyquist and Bode plot in Matlab.
5. To calculate the controllability and observability of the given continuous and discrete time systems using Matlab.
6. To find the stability range of controller gain K using root locus method for the given continuous and discrete time systems using Matlab.
7. To study the modern optimisation techniques (e.g. GA, PSO) using Matlab programming.
8. Simulation studies of open loop inverted pendulum system
9. State feedback controller design for inverted pendulum system.
10. Full order and reduced order state observer design for inverted pendulum system.
11. Simulation studies of open loop twin rotor MIMO system
12. State feedback controller design for twin rotor MIMO system
13. Full order and reduced order state observer design for twin rotor MIMO system.
14. To study the response of a rotary pendulum system using PD and PID controllers.
15. To study the response of magnetic ball suspension system using PD and PID controller in Matlab.
16. To study the response of magnetic ball suspension system using PD and PID controller in Labview.

Part B: Real time Experiments

17. To study the real time PID control for inverted pendulum system.
18. To study the real time PD and PID controller for rotary pendulum system.
19. To study the real time PID control for twin rotor MIMO system.
20. To study the real time PD and PID controller for magnetic ball suspension system using Matlab.
21. To study the real time PD and PID controller for magnetic ball suspension system using Labview.

17.10.17

EE 22301 Robot Modeling and Control **SECOND SEMESTER (E-IV)**

Basic Concepts in Robotics, Robotics system components, Homogeneous Transformation, Representation of Transformations, Direction cosine representation, Basic and Composite Rotation matrices, Rotation matrix with Euler angle representation, Specification for position and orientation of end-effectors, Robot arm Kinematics: The direct kinematics problem, Inverse Kinematics for euler angles and Direction cosine angle, Denavit Hartenberg convention and its applications, Robot arm Dynamics: Forward Dynamics, Inverse Dynamics, Lagrange-Euler formation and Applications., Actuators- Hydraulic actuators, Pneumatic actuators, Electrical Actuators, DC Servo motor and other actuators. Sensors- Positional and velocity sensors, Tactile sensors, proximity and range sensors, Force and Torque sensors, Uses of sensors in robotics.

References:

1. John J. Craig, "Introduction to robotics, mechanics and control," Prentice Hall; 3 edition, 2004.
2. John J. Craig, "Adaptive control of mechanical manipulators," Addison-Wesley Pub (Sd), 1987.
3. F.L. Lewis, S. Jagannathan, A. Yesildirek, "Neural network control of robot manipulators," CRC Press, 1998.
4. F. L. Lewis, Abdallah C. T., and Dawson D.M., "Control of robot manipulators," Macmillan Publishing Co, Oxford, UK, 1993.

11·10·12

The linear-Quadratic problem-formulation and solution; LQG problem; Frequency domain interpretations; loop transfer recovery; robustness issues; H_2 optimization; small gain theorem; H_∞ optimality-motivation, the standard set up. Co-prime factorization, the model-matching problem, state space solutions.

References:

1. K.Zou, J.C.Doyle , "Essentials of robust control," Prentice Hall; 1 edition, 1997.
2. M. Green, D. Limebeer, "Linear robust control," Dover Publications; Reprint edition, 2012.
3. Kwakernak and Sivan, "Linear Optimal Control," Wiley-Blackwell, 1972.
4. Anderson and Moore , "Linear Optimal Control" Prentice-Hall 1990
5. B.A. Francis, "A Course in H_∞ Control Theory," Springer Verlag 1987.

11.10.17

Introduction to digital system simulation, continuous and discrete system simulation, Queuing system simulation, A PERT network simulation, Inventory control system simulation and forecasting techniques, Design and evaluation of experiments on system simulation, system simulation languages with particular reference to GPSS, SIMULA & Continuous system simulation languages (CSSLs), Introduction to system models. Approximation of functions: Linear regression, polynomial regression, Fitting of exponential and trigonometric functions, Taylor Series, Chebyshev series and rational functions approximations. Differentiation and Integration: Formulae for numerical differentiation, numerical integration, Simpson's rule.

References:

1. John F. Wakerly, "Digital design principles and practices," Prentice Hall; 4th edition, 2005.
2. G. Borriello, R. H. Katz , "Contemporary logic design," Pearson Prentice Hall, 2005.
3. Howard G. Johnson, "High-speed digital design- A handbook of black magic," Prentice Hall; 1 edition, 1993.
4. M. Abramovici, M. Breuer & A. Friedman, "Digital systems testing and testable design," Wiley-Blackwell; Revised edition, 1994.

17.10.17

Describing the System: Problem formulation, state variable representation, static optimization-optimization without constraints, optimization with equality constraints.

Optimal Control of Continuous-time System: The calculus of variation, fundamental concepts, functional of a single function, functional involving several functions, continuous-time LQR, steady state closed-loop control and sub-optimal feedback, tracking problems.

Optimal Control of Discrete-time System: Solution of the general discrete-time optimization problem, discrete-time LQR, digital control of continuous-time systems, frequency domain results.

Dynamic Programming: Bellman's principle of optimality, computational procedure for solving control problems, continuous-time systems, discrete-time systems, Hamilton-Jacobi-Bellman equation, linear regulator problems.

Robustness and Multivariable Frequency-domain Techniques: analysis, robust output-feedback design, Observers and Kalman filter LQG/loop-transfer recovery, H-infinity design.

References:

1. A. P. Sage, "Optimal System Control," Prentice-Hall, Englewood Cliffs, New Jersey, 1968.
2. D. E. Kirk, "Optimal Control Theory- An Introduction," Dover Publications, 2012.
3. Frank L. Lewis, D. L. Vrabie, V. A. Syrmos, "Optimal Control," New York: Wiley, 3 edition, 1986.
4. Lawrence Ç. Evans, "An Introduction to Mathematical Optimal Control Theory," University of California, Berkeley 2010,
5. Richard Weber, "Optimization and Control," University of Cambridge, 2010.
6. Brian D. O. Anderson and John B. Moore, "Optimal Control: Linear Quadratic Methods," Dover Publications Inc. , 2007

Model Order Reduction: Importance of reduced order models, Time domain Techniques, Frequency Domain Classical techniques, Optimal Hankel Norm Approximation. Sliding mode control: Concept of variable-structure controller and sliding control, reaching condition and higher order sliding mode, reaching mode, implementation of switching control laws. Reduction of chattering in sliding and steady state mode. Fuzzy Logic: Fuzzy arithmetic and fuzzy relations, Fuzzy logic controller, Adaptive fuzzy control, Stabilization using fuzzy models Microcontroller and DSP control

References:

1. G. Obinata and B.D.O. Anderson, "Model reduction for control system design," Springer-Verlag, London, 2001.
2. M. Jamshid, "Large-Scale Systems: Modeling, Control and Fuzzy Logic," Prentice Hall; 1st edition, 1996.
3. J. J. E. Slotine, "Applied nonlinear control," Prentice Hall Englewood Cliffs, New Jersey. 1991.
4. M. Chidambaran, "Computer Control of Processes," Alpha Science International Ltd, 2002.
5. V. I. Utkin, "Sliding modes in control and optimization," Springer- Verlag, 1992.
6. W. Pedrycz,"Fuzzy control and fuzzy systems," Research Studies Press, 1993.

EE 22312 Introduction to Probability Theory & Stochastic Process

Discrete-type random variables - random variables and probability mass function, mean and variance, conditional probabilities -independence, Bayes' formula - discrete distributions: Bernoulli, binomial, geometric, Poisson maximum likelihood estimation, Continuous-type random variables - cumulative distribution functions, probability density function - independence, Bayès' formula – continuous distributions: uniform, exponential, Gaussian, chi-square - functions of random variables , Joint distributions, transformation of probability functions under maps, joint Gaussian distribution, Minimum mean square error estimation, Basic ideas of the probabilistic method-the first and second moment techniques.

References:

1. Robert Brown and Patrick, Hwang, "Introduction to Random Signals and Applied Kalman Filtering," 3rd Ed, John Wiley and Sons Inc. 1997.
2. Goong Chen, Guanrong Chen, Shih-Hsun Hsu, "Linear stochastic control system," CRC Press, 1995.
3. Jason L. Speyer and Walter H. Chung, "Stochastic Processes, Estimation and Control," PHI, 2013.
4. J. S. Meditch, "Stochastic Optimal Estimation and Control," New York, McGraw Hill 1969.
5. M. Mitzenmacher and E. Upfal, "Probability and computing: Randomized Algorithms and Probabilistic Analysis," Cambridge University Press, 2005.
6. P.E. Pfeiffer, "Conditional Independence in Applied Probability," Birkhäuser; 1979
7. Dimitri P. Bertsekas and John N. Tsitsiklis, "Introduction To Probability," Athena Scientific; 2nd edition (1 June 2008)

11.10.13

EE 22313 System Identification & Estimation **SECOND SEMESTER (E-V)**

System Identification - Motivation and Overview, random variables and stochastic processes, stochastic static models, Disturbance models - random processes, representation of stationary processes, white-noise process, auto-covariance function (ACF), ARMA models. Parametric model structures - ARX, ARMAX etc.

The identification problem, classical methods of identification of transfer functions models, Linear Regression - Least Squares estimates, Statistical properties of LS Estimates. Weighted Least Squares, Recursive Least Squares, Maximum Likelihood Estimation. Minimum variance algorithm, stochastic approximation. Estimation of non-parametric models - impulse /step response coefficients, frequency response models. Estimation of parametric models - notions of prediction and simulation, predictors for parametric models, prediction-error methods, Instrumental Variable method. Kalman-filters for state estimation Gauss Markov, Model for vector random processes. Model Structure Selection and Diagnostics - estimation of delay and order, residual checks, properties of parameter estimates, model validation.

References:

1. Pieter Eykhoff, "Trends and progress in system identification," Pergamon, 1981.
2. Raman K. Mehra, "System identification advanced and case studies," Elsevier Science; 1 edition, 1976.
3. Jason L. Speyer, Walter H. Chung, "Stochastic processes, estimation and control," Society for Industrial and Applied Mathematics, 2008.
4. Gregory F. Lawler, "Introduction to stochastic processes," Chapman and Hall/CRC; 2 edition, 2006.

Introduction: Linear feedback, effects of process variations, adaptive schemes, adaptive control problem.

Real-Time Parameter Estimation: Least squares and regression models, estimating parameters in dynamical systems, simulation of recursive estimation.

Self-tuning Regulators (STR): Pole placement design, indirect STR, direct STR, stochastic and predictive STR, applications.

Model-reference Adaptive Control (MRAC): The MIT rule, determination of adaptive gain, design of MRAS using Lyapunov theory, BIBO stability, output feedback, relation between MRAS and STR, applications.

Gain Scheduling: The principles, design of gain scheduling controllers, nonlinear transformations, applications.

Robust adaptive control scheme, averaging-based analysis, adaptive control of nonlinear systems.Practical issues and implementation, commercial products and applications.

References:

1. K. J. Astrom, B. Wittenmark, "Adaptive Control, Prentice Hall," 2 edition, 1994.
2. P. A. Ioannou, J. Sun, "Robust Adaptive Control, Dover Publication," 2 edition, 2012.
3. H. K. Khalil, "Nonlinear Systems," Prentice Hall; 3 edition, 2001.
4. K. S. Narandra, A. M. Annaswamy, "Stable Adaptive Systems," Prentice Hall, Englewood Clis, NJ, 1989.
5. S. Sastry, M. Bodson, "Adaptive Control: Stability, Convergence and Robustness," Dover Publications, 2011.

11.10.12

1. Study and experimentation on displacement measurement using LVDT.
2. Study and experimentation on speed Measurement.
3. Study and experimentation on pressure measurement.
4. Study and experimentation on Piezoelectric transducers for force/ Load measurement.
5. Study and experimentation on temperature sensing transducers such as thermocouple, thermistor, and RTD.
6. Study and experimentation on Strain Gauge measurement.
7. Design, fabrication and testing of active filters.
8. Design, fabrication and testing of instrumentation amplifiers.
9. Study and interfacing of converters of digital to analog.
10. Study and interfacing of converters of Analog to digital.
11. Study and Interfacing of Sample and Hold circuit.
12. Interfacing of Displacement transducers with Microprocessor 8085/8086.
13. Interfacing of Temperature transducers with Microprocessor 8085/8086.
14. Study of Process Control Trainer for various control applications.
15. Study and Experimentation of NIELVIS.
16. Experimentation using BNC 2120.
17. Data Acquisition and Instrument Simulator using LabVIEW.
18. Study and Experiments using PXI systems.