I SEMESTER

18EA01/18EE01/18ED01/18EM01/18UC01 MATHEMATICS OF SYSTEMS ENGINEERING 2 2 0 3

VECTOR SPACES: Real vector spaces, subspaces, linear independence – basis and dimension of a vector space - inner product space, orthonormal bases, Gram-Schmidt process. (8+7)

LINEAR TRANSFORMATIONS: General linear transformations, kernel and range, inverse linear transformations, matrices of general linear transformations, eigenvalues and eigenvectors, diagonalization. (8+7)

CALCULUS OF VARIATIONS: Variational problems of fixed boundaries: Variations and its properties - simplest variational problems – Euler equation – Brachistochrone problem – variational problems involving several unknown functions – Functional involving first and second order derivatives. (8+7)


REFERENCES:

18UC02 SMART SENSORS AND NETWORKS 3 0 0 3


STANDARDS FOR SMART SENSING: Setting Standards for Smart Sensors and Systems - IEEE 1451 family of standards - Network-Capable Application Processor, Network Communication Models, Smart Transducer Interface Module, Transducer Electronic Data Sheet, Transducer-Independent Interface, Calibration/Correction Engine - Extending System to the Network (11)

WIRELESS SENSOR NETWORKS: Challenges in wireless sensor networks - Single node architecture - Hardware components, energy consumption of sensor nodes - Network architecture - Sensor network scenarios: Types of sources and sinks, single hop versus multi-hop networks, multiple sinks and sources - Design principles and applications of WSNs - Bluetooth sensor networks - IEE 802 sensor networks. (11)

REFERENCES:

18UC03 DYNAMICAL SYSTEMS AND CONTROL 3 2 0 4

MATHEMATICAL DESCRIPTION OF SYSTEM: Causality – Lumpedness – Linearity – Linearization- Concept of state, state variables and state model - State space representation using physical, phase and canonical variables - Comparison of input-output description and state variable description- MIMO systems- Discretization of a continuous time model. (11+7)


CONCEPT OF CONTROLLABILITY AND OBSERVABILITY: Kalman’s and Gilbert’s test for controllability– Pole assignment by state feedback using Ackermann’s formula Kalman Canonical form – Controller design using output feedback – Controllability of Discrete LTI systems – Controllability of linear time variant systems. Kalman’s and Gilbert’s test for observability - Design of full
order observer using Ackermann’s formula – Observable canonical form – Duality – Observer based controller design – Reduced order observer design – Observability of Discrete LTI Systems – Observability of linear time variant systems (11+8)


REFERENCES:

18UC04 ADVANCED PROCESS CONTROL


CONTROLLER TUNING & FINAL CONTROL ELEMENT: Evaluation criteria – Tuning: Process reaction curve method, Continuous cycling method and Damped oscillation method – Auto tuning – Pneumatic and Electric actuators – Types of control valves – Characteristic of control valves – Control valve sizing – Cavitation and flashing (15)


REFERENCES:

18UC05 EMBEDDED SYSTEMS


DIGITAL CONTROLLERS: Digital control system- Sensors and Actuators - Signal conditioning and Driver circuits - Discretization - Digital realization of controllers- Proportional-Integral-Derivative (PID) Controller-Hardware implementation considerations- Fixed and Floating point number representation-IEEE 754-Floating point emulation-Fixed point implementation of control algorithms. (11+7)


REFERENCES:

18UC51 OBJECT COMPUTING AND DATA STRUCTURES LABORATORY

LABORATORY COMPONENT:
Object Computing and Data Structures Laboratory course highlights the difference between procedure oriented programming and object oriented programming. It gives an idea about the basic concepts of OOP. After completing this course a brief knowledge about the concepts in object-oriented programming can be obtained. This course also gives a clear understanding on Data Structures and its type. It deals with the linear data structures and their algorithms. It explores the basic sorting techniques in data structures with their algorithm.

Object Computing (Using C++):
Implementation of the following problems:

1. Implementation of classes and object for simple arithmetic operations.
2. Implementation of array of objects and dynamic objects.
3. Implementation of Static members.
5. Implementation of friend functions, inline functions and default arguments.
6. Implementation of constructors and destructors.
7. Implementation of inheritance and its types

Data Structures (Using C or C++):

1. Program using arrays.
2. Representation of Sparse & dense Matrix using arrays.
3. Implementation of Stacks using array.
4. Application of Stack: Conversion of infix to postfix expression
5. Implementation of queue using array.
7. Implementation of various sorting algorithms.

REFERENCES:

II SEMESTER

18UC06 SYSTEM IDENTIFICATION


STATE SPACE MODEL IDENTIFICATION: Informative Data- Input design for identification- Data pre-processing- Model development- Identification of State-Space Models: Kalman filter- Foundations for subspace identification- Subspace identification algorithms

REFERENCES:

18UC07 NONLINEAR CONTROL


FEEDBACK LINEARIZATION: Method of feedback linearization - Mathematical tools: Lie derivatives, lie brackets, involutive condition, Frobenius theorem - Input-state linearization of SISO systems - Input-output linearization of SISO Systems - Internal dynamics and zero dynamics. (8+7)

SLIDING MODE CONTROL AND BACKSTEPPING CONTROL: Basic concepts of variable structure systems - Sliding surfaces - Filipov's construction of equivalent dynamics - Conditions for existence of sliding regions. Backstepping control - Case Study: Backstepping method for non-feedback linearizable systems. (8+7)

REFERENCES:

Total L:32 + T:28 = 60

18UC08 STATE ESTIMATION


PARTICLE FILTER: Particle filtering - SIS filtering algorithm - Degeneracy phenomenon-SIR Particle filter - Implementation issues - Sample Impoverishment – Selection of proposal density - Particle filter with EKF as proposal - Unscented Particle filter - Case Studies. (11)

DECENTRALIZED ESTIMATION FOR MULTISENSOR SYSTEMS: Multisensor systems - Decentralized systems - Information Filter - Decentralized Estimators - Decentralized information filter - Decentralized Kalman filter - Limitations of fully connected Decentralization. (11)

REFERENCES:

Total L:45

18UC09 INDUSTRIAL AUTOMATION

PROGRAMMABLE LOGIC CONTROLLER (PLC) BASICS AND PROGRAMMING: Overview of PLC systems - input/output modules-power supplies and isolators - Memory mapping - PLC programming Languages - PLC ladder diagram programming using timers and counters - Programming using advanced PLC functions. (11)

PLC APPLICATIONS & SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEMS (SCADA): Analog PLC operation - PID function - Design of interlocks and alarms using PLC – Safety PLCs - Case study on industrial applications of PLC - Elements of SCADA - Functionality of SCADA - Master Terminal Unit (MTU) - Remote Terminal Unit (RTU) - Interfacing PLC and SCADA using communication link. (11)

DISTRIBUTED CONTROL SYSTEM AND INDUSTRIAL COMMUNICATION STANDARDS: Different architectures – Local Control unit - Operator Interface – Displays - Engineering interface - Redundancy concept - Factors to be considered in selecting DCS -
Communication facilities: HART Protocol, Wireless HART. Foundation Field bus, PROFIBUS, MODBUS - Case Study of any one DCS.

ADVANCES IN INDUSTRIAL AUTOMATION: Process data analytics, Cloud based automation, Industrial Internet of Things (IIoT)

REFERENCES:

18UC52 INDUSTRIAL AUTOMATION LABORATORY

In this course, students initially will be provided with an orientation program about the hardware pilot process plant and software used for process automation. In addition to this, every week students will be given theoretical inputs related to the problems defined for about two hours. These problems are about development of ladder logic for sequential control applications using programmable logic controllers and development of control strategies for continuous control of pilot process plants using distributed control system. Each student is expected to solve a control problem given to them and simulate to test the performance of the solution provided by them and, finally implement in real time. A report is to be submitted based on the results obtained with inference.

Total: P: 60

18UC61 INDUSTRY VISIT & TECHNICAL SEMINAR

The student will make at least two technical presentations on current topics related to the specialization. The same will be assessed by a committee appointed by the department. The students are expected to submit a report at the end of the semester covering the various aspects of his/her presentation together with the observation in industry visits. A quiz covering the above will be held at the end of the semester.

Total: P: 60

III SEMESTER

18UC53 ADVANCED CONTROL LABORATORY

In this course students will be provided with an orientation program on the equipment and software facilities available in the department connected with this lab. In addition to this, every week students will be given theoretical inputs related to the problems defined for about two hours. Based on which every student is instructed to work with different mathematical models of systems for the problems defined. These models should be minimum of order four and can represent stable/unstable, minimum/non-minimum phase systems, and should have been obtained from standard literature. The focus of the problems defined are to implement state estimator, multivariable controller, optimal and adaptive controllers on the models considered. Few of the above exercise is also carried out based on the mathematical models of bench mark systems available in the department, to perform real time control. A report is to be submitted based on the results obtained with inference.

Total: P: 60

18UC71 PROJECT WORK - I

- Identification of a real life problem in thrust areas
- Developing a mathematical model for solving the above problem
- Finalisation of system requirements and specification
- Proposing different solutions for the problem based on literature survey
- Future trends in providing alternate solutions
- Consolidated report preparation of the above

Total P: 90

IV SEMESTER

18UC72 PROJECT WORK – II

The project involves the following:
- Preparing a project - brief proposal including
  - Problem Identification
• A statement of system / process specifications proposed to be developed (Block Diagram / Concept tree)
• List of possible solutions including alternatives and constraints
• Cost benefit analysis
• Time Line of activities

• A report highlighting the design finalization [based on functional requirements & standards (if any)]

• A presentation including the following:
  • Implementation Phase (Hardware / Software / both)
  • Testing & Validation of the developed system
  • Learning in the Project

• Consolidated report preparation

Total P: 420

PROFESSIONAL ELECTIVE THEORY COURSES

18UC21 ADAPTIVE CONTROL


DETERMINISTIC SELF-TUNING REGULATORS: Pole Placement design - Indirect Self-tuning regulators – Continuous-time self tuners - direct self-tuning regulators – Disturbances with known characteristics (11)


Total L: 45

REFERENCES:

18UC22 ROBUST CONTROL

UNCERTAINTY AND ROBUSTNESS: Concepts of model uncertainty, including both parametric and dynamic uncertainty - Fundamental concept of robustness and the relationship between physical systems and mathematical models - Mathematical background including norms for vectors, matrices, signals, and systems - Co prime Factorization and stabilizing controllers, singular value decomposition and its application to perturbation analysis. (11)


LOWER ORDER CONTROLLERS: Absolute-error Approximation Methods, Reduction via Fractional Factors, Relative-error Approximation Methods, Frequency Weighted Approximation Methods. (11)

Total L: 45

REFERENCES:

220
18UC23 INDUSTRIAL DRIVES AND CONTROL

**DC MOTOR DRIVES:** Electrical drives, Fundamental torque equations, Speed torque conventions and multiquadrant operation, Components of load torques, Nature and classification of load torques, State space model of DC motor drive, Single-phase and Three-phase drives: Half converter, Semi converter, Full converter and Dual converter fed drives - Two quadrant and four quadrant chopper controlled drives – Closed loop control of DC drives

**INDUCTION MOTOR DRIVES:** Performance characteristics, Stator Control: Stator voltage control, Rotor voltage control, Frequency control, Voltage and frequency control, Current control, Voltage, current and frequency control - Rotor resistance control: Conventional methods, Static rotor resistance control - Slip power recovery: Static Kramer drive, Static Scherbius drive.


**SYNCHRONOUS AND SPECIAL DRIVES:** Synchronous Motor Drives: Open loop volts/hertz control, Self control model Permanent magnet ac motor drives, Brushless dc motor drives, Sensorless control - Stepper motor and Switched reluctance motor drives.

**REFERENCES:**

Total L: 45

18UC24 APPLIED SOFT COMPUTING


**NEURO-FUZZY CONTROL 1:** Feedback control systems and Neuro-Fuzzy control - Inverse learning - Specialized learning - Back propogation through time and Real-time recurrent learning - Case studies: The inverted pendulum system.

**NEURO-FUZZY CONTROL 2:** Reinforcement learning control – Gradient free optimization – Gain scheduling Fuzzy controller – Feedback linearization of sliding control - Case studies: Cart and pole system with a varying pole length.

Total L: 45

**REFERENCES:**

18UC25 ROBOTIC SYSTEMS


**ROBOTIC VISION:** Image formation -Image processing and analysis - Vision applications: Detection, Recognition and Tracking-Camera geometry and calibration

**JOINT CONTROL:** Linear control of robotic manipulators – Second-order systems – Modeling and control of single joint – Performance of feedback control system-Implementation issues- Architecture of industrial robotic controllers - Case studies

Total L: 45

221
REFERENCES:

18UC26 MACHINE VISION


IMAGE ENHANCEMENT AND RESTORATION: Spatial domain enhancement: gray level transformations - histogram processing-edge detection - Frequency domain enhancement: filtering in frequency domain- smoothing frequency domain filters-sharpening frequency domain filters- homomorphic filtering- Noise models- Restoration by order statistics filter - Inverse filtering - Wiener filtering. (11)

IMAGE REPRESENTATION AND SEGMENTATION: Chain code – Fourier descriptor- Bspline representation- Convex hull-Detection of discontinuities: point, line and edge detection-Edge linking and boundary detection-Threshholding: global threshholding-optimal threshholding- local threshholding- thresholds based on several variables- Region based segmentation: basic formulation-region growing- region splitting and merging. (11)


REFERENCES:

18UC27 OPTIMAL CONTROL

CALCULUS OF VARIATIONS AND OPEN LOOP OPTIMAL CONTROL: State variable representation of systems- Performance measures for optimal control problems - Selection of performance measures – Calculus of variations – Definitions– The basic variational problem - Extrema of functions and functional with conditions – Variational approach to optimal control system- Discrete time optimal control system-: Variational calculus, Fixed final state and Free-final state open loop optimal control (12)

LINEAR QUADRATIC OPTIMAL CONTROL SYSTEM: Problem formulation – Finite time Linear Quadratic regulator – Infinite time LQR system: Time Varying case- Time-invariant case – Stability issues of Time-invariant regulator – Linear Quadratic Tracking system: Finite time case and Infinite time case - Discrete time linear state regulator system – Steady state regulator system-Case studies (11)


REFERENCES:

18UC28 ADVANCED DIGITAL SIGNAL PROCESSING


MULTIRATE SIGNAL PROCESSING: Downsampling- Upsampling – Commutativity of upsampling and down sampling- Multirate identities – Polyphase representation – Fractional sampling rate conversion - Multistage implementation of decimation and interpolation- Two channel filter bank, M channel filter bank:Perfect reconstruction criterion- Applications of filter bank in speech and image coding. (11)


REFERENCES:

18UC29 OPTIMIZATION TECHNIQUES 3 0 0 3


UNCONSTRAINED OPTIMIZATION: Direct search methods - Univariate method, Pattern search method, Simplex method, Descent methods - Steepest Descent method, Conjugate gradient method, Quasi Newton method. (11)


DYNAMIC PROGRAMMING: Multistage decision process, Suboptimization and Principle of Optimality, Computational procedure, Final value problem to initial value problem, Linear Programming as a Case of Dynamic Programming, Continuous dynamic programming. (11)

REFERENCES:

18UC30 WAVELETS AND APPLICATIONS 3 0 0 3


CONTINUOUS WAVELET TRANSFORM: Wavelet basis – concept of scale and its relation with frequency, Continuous time Wavelet Transform equation – series expansion using waves – CWT – Admissibility condition – Multi Resolution Analysis (MRA) (11)


APPLICATIONS OF WAVELETS: Power signal analysis - Signal Denoising - Sub-band coding of speech and music – Image Compression (11)

REFERENCES:

Total L: 45

Total L:45

Total L:45

Total L: 45
18UC31 MULTI SENSOR DATA FUSION


DECENTRALIZED ESTIMATION FOR MULTISENSORY SYSTEMS: Multi sensor systems, Decentralized systems, Decentralized estimators, limitations of fully connected decentralization. Scalable decentralized estimation – Nodal transformation. Distributed and decentralized Kalman and Information Filters.

HIGH PERFORMANCE DATA STRUCTURES: Tessellated, trees, graphs and function. Representing ranges and uncertainty in data structures. Designing optimal sensor systems with in dependability bounds. Implementing data fusion system.

REFERENCES:

Total L: 45

18UC32 SLIDING MODE CONTROL


DESIGN APPROACHES: Regular form based approach, robust eigen structure assignment, quadratic minimisation, direct eigen structure assignment. Incorporation of tracking requirement, model reference approach, integral action approach.

CONTROLLER DESIGN USING OUTPUT INFORMATION: Problem formulation, special case square plants. General frame work, hyperplane design, control law synthesis. Dynamic compensation, model reference system using only outputs.

HIGHER ORDER SLIDING MODES: Definitions, higher order sliding modes in control systems, sliding order and dynamic actuators, 2-sliding controllers, arbitrary order sliding controllers. Sliding mode observers

REFERENCES:

Total L: 45

18UC33 FAULT DIAGNOSIS AND CONTROL


Total L: 45
REFERENCES:

18UC34 MATHEMATICAL METHODS FOR PROCESS DATA ANALYTICS
3 0 0 3


REFERENCES:

AUDIT COURSES

18UC81 ENGLISH FOR RESEARCH PAPER WRITING
vide Automotive Engineering 18AE81

18UC82 RESEARCH METHODOLOGY AND IPR
vide Automotive Engineering 18AE82