Curriculum

MS Systems Engineering

DEPARTMENT OF ELECTRICAL ENGINEERING

PAKISTAN INSTITUTE OF ENGINEERING AND APPLIED SCIENCES (PIEAS)

NILORE, ISLAMABAD
## SEMESTER-WISE COURSE PLAN

### SUMMARY

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
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<td>Summer</td>
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<td>Process Instrumentation</td>
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Ms. Systems Engineering Curriculum approved in the meeting of Academic Committee held on November 17, 2011
# SEMESTER-WISE COURSE PLAN

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<tr>
<th>SR.NO</th>
<th>CODE</th>
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<th>CrHrs</th>
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# DETAILED SEMESTER-WISE COURSE PLAN

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<th>SR.NO</th>
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<td>Stochastic Processes</td>
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<td>EE-616</td>
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<td>EE-606</td>
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Detailed Course Contents

EE-425 FUNDAMENTALS OF ROBOTICS

Course Contents
Kinematics; Dynamics; State variable representation and linearization of nonlinear models; motion planning, motion control, trajectory planning; mechanisms and actuation; Sensors; Robotic system architecture and programming; mobile robotics, types and classification, localization and mapping; kinematically redundant manipulators, parallel mechanisms; robots with flexible joints; Programming in player/stage simulator; case studies: PUMA560, RHINO XR3, SCARA, STANDFORD ARM.

Recommended Texts

EE-426 PLCs AND INDUSTRIAL AUTOMATION

Course Contents
Introduction to Programmable Logic Controllers; Ladder Logic programming, PLC connections, Ladder Logic Inputs and Outputs, PLC Hardware; Input and Output Modules, Relays, Logical Sensors, Sensor wiring, Presence detection of Contact Switches, Reed Switches, Optical Sensors, Capacitive Sensors, Logical Actuators, Solenoids, Valves, Hydraulic and Pneumatic Actuators, Motors. Boolean Logic Design details; PLCs Operation, Latches Timers, Counters. Structured Logic Design. State Based Design; Handling numbers and data; Using PLC memory bits; Data handling using ladder logic functions; Structured Text Programming; Function Block Programming; Analog Inputs and Outputs, Continuous Control, PID Control, Serial Communication, Networking, Human Machine Interface (HMI), SCADA and its use.

Recommended Texts:
4. PLC manufacturers Material in PDF (e.g., Siemens), Latest available.

EE-501 CONTROL SYSTEMS DESIGN-I

Course Contents
Review of modeling and analysis technique for control systems; Bode diagram, Nyquist plot, polar plot, Nichols chart, Nyquist stability criterion, relative stability, Modeling of different benchmark systems and related transfer functions, Design of control systems using root locus techniques, control system design by frequency response; lag compensation, lead compensation, lag-lead compensation, PID controllers; tuning rules for PID controllers, Two degree of freedom PID control, Fundamental limitations in SISO control; sensors, actuators, model, error and structural limitations,
industrial applications, remedies, Dealing with constraints; wind-up, anti wind-up schemes, state saturation,

**Recommended Texts:**


**EE-506 EMBEDDED SYSTEMS**

**Course Contents**

Introduction to Embedded Systems; C8051FXXX/ARM series advanced Processors Architecture, Memory Organization and Real World Interfacing; Devices and Communication Buses for Devices Network; Device Drivers and Interrupt Service Mechanisms; Program modeling concepts, Inter process communications and synchronization of processes, threads and tasks, Real time operating systems, case studies: programming with RTOS in Micro C OS-I/RT-Linux/Windows CE

**Recommended Texts:**

EE-507 STOCHASTIC PROCESSES

Course Contents
Review of basic probability; Conditional probability; Random variables and transformations; Random vectors their transformations; Jointly Gaussian random variables; Sequences of random variables: Laws of large numbers, central limit theorem; Basic concepts of random processes; Special processes: Gaussian, Markov, Wiener, Poisson processes, random walk; Random processes in linear systems and Wiener filtering; Principles of Estimation Theory; sample mean and sample variance; maximum-likelihood estimator; Orthogonality principle, minimum mean squared error estimation and Kalman filtering; Introduction to Bayesian estimation.

Recommended Texts

EE-508 COMPUTATIONAL INTELLIGENCE

Course Contents
Basic concepts of computational intelligence; single-layer and multi-layer feedforward neural networks; feedback and recurrent neural networks; learning vector quantizer (lvq); self-organizing feature maps; radial basis function neural networks; support vector machines; genetic algorithms, genetic programming; fuzzy sets and fuzzy logic, fuzzy neural networks; swarm intelligence and ant colony optimization, hidden markov models.

Recommended Texts

EE-509 NUMERICAL OPTIMIZATION

Course Contents
Optimization theory; problems; unconstrained nonlinear problems, linear equality constrained problems, linear inequality constrained problems, nonlinear equality constrained problems, nonlinear inequality constrained problems, methods; linesearch methods, trust-region methods, Newton's methods, linear and nonlinear conjugate gradient methods, simplex method, penalty function methods, barrier function methods, augmented Lagrangian methods, sequential linearly constrained methods, Convex optimization, sequential quadratic programming methods

Recommended Texts
Ms. Systems Engineering Curriculum approved in the meeting of Academic Committee held on November 17, 2011


EE-510 PROCESS INSTRUMENTATION

Course Contents
Measurement techniques and sensors for various process variables: length, motion, angle, force, weight, torque, pressure, flow, temperature, humidity, liquid level, time, frequency, etc; Properties of sensors: static and dynamic response, calibration, sensitivity, resolution, repeatability, reproducibility, size, weight, dimensions, fatigue life, reliability, errors, aging, pricing and availability, system reliability, etc; Manipulating, computing, and compensating devices: bridge circuits (ac/dc), amplifiers, integrators, instrumentation amplifiers, modulation and demodulation, voltage-to-frequency and frequency-to-voltage converters, grounding and shielding, filtering; Dynamic compensation: pole placement; Interfacing with microprocessors, Analog/digital inter-conversion; Data Transmission: analog voltage and current, digital data, radio transmission, pneumatic transmission, slip rings; Display: analog voltmeters and potentiometers, digital voltmeters, XY plotters, oscilloscopes;.

Recommended Texts:

NE-510 NUCLEAR POWER PLANT SYSTEMS

Course Contents
Layout of nuclear power plants; Containment buildings; Primary containment vessels; Structure of reactor core; and mechanical stress in various structures. Description and analysis of power plant systems and components including steam generator, steam dryer and separator, pressurizer, reheater, heat exchanger, condenser, demineralizer, pumps, turbine, generator, cooling tower; Auxiliary cooling systems. Fuel handling mechanisms; Control and mechanisms; Radwaste systems; Electrical Systems; Reactor grid interface and load following. Basic considerations in nuclear plant design; Components of nuclear power cost; Economic comparison of nuclear and fossil fueled plants; Dual and multipurpose nuclear plants; Future trends in nuclear power cost.

Recommended Texts

**EE-511 DIGITAL CONTROL SYSTEMS ANALYSIS AND DESIGN**

**Course Contents**

Z-transform review and applications; Sampling, Quantization, and discretization; Delta Modulation; Stability Tests; Digital control systems analysis and design using root locus and frequency domain; Dead beat design; Direct design method of Ragazzini; State-Space analysis; Different canonical forms; Cayley-Hamilton Theorem; Stability in the Sense of Lyapunov; Concepts of Controllability and Observability; Pole Assignment Techniques; Design of Static State Feedback Gain matrix; Design of Full Order Prediction and Current Observer; Design of Reduced Order Prediction Observer, Minimum Order Estimator Design; Pulse Width Modulation (PWM) control technique; Bang-Bang Control; Design of Servo-System with and without observer.

**Recommended Texts:**

2. Franklin, Powell, Digital Control of Dynamical Systems, 3rd Ed., 2005

**EE-515 ADVANCED DIGITAL SIGNAL PROCESSING**

**Course Contents**

Review of discrete time systems, digital filters, and filter structures; Multi-rate digital signal processing fundamental: Basic sample rate alteration devices, multi-rate structures for sampling rate conversion, multi-state design for decimator and interpolator, poly-phase decomposition, arbitrary-rate sampling rate converter; Multi-rate filter banks: Digital filter banks, Two-channel quadrature-mirror filter bank, Perfect reconstruction two channel FIR filter banks, L-Channel QMF banks; Parametric signal modeling and linear prediction theory: Stochastic time-series models; Wold decomposition theorem; Discrete Wiener filters: principle of orthogonality, normal equations; linear prediction theory: forward and backward linear predictors and their properties, Levinson-Durbin algorithm, lattice prediction filter; Spectral Estimation: Parametric, nonparametric methods; Analysis of finite word length effects; (Optional)signal-to-noise ratio in low-order IIR filters, (Optional)low-sensitivity digital filters, round off errors in FFT algorithms.
Recommended Texts


EE-522 PATTERN RECOGNITION

Contents
Supervised and unsupervised classification and recognition, Feature generation and selection: feature vectors, dimensionality reduction, principal component analysis, independent component analysis, Fourier features, wavelet features, signal and noise subspace; Distance functions, measures, metrics; Baye’s decision theory; Parametric/nonparametric estimation of probability density functions: maximum likelihood estimation, expectation maximization, histograms, kNN classifiers, least square methods; Linear/nonlinear classifiers; LMS, perceptron, support vector machines (SVM); Kernel methods; Neural networks: multilayer perceptron, back propagation, radial basis functions, competitive learning, vector quantization; Template matching. Context dependent classification; Clustering; sequential, hierarchical, fuzzy, probabilistic, possibilistic clustering, mixture decomposition and expectation maximization, clustering using graph theory, decision trees; Morphological clustering; System evaluation and cluster validity;

Recommended Texts:


PAM-524 LINEAR ALGEBRA

Course Contents
Basics of linear algebra: Gaussian elimination and matrices, two-point boundary value problems, ill-conditioned systems, homogeneous & nonhomogeneous systems, electrical circuits, matrix algebra, matrix inversion, factorization, elementary matrices & equivalence, determinants and its properties; Vector spaces: spaces and subspaces, four fundamental subspaces, linear independence, basis and dimension, classical least squares, change of basis and similarity, invariant subspaces, linear transformations, normed spaces, metric vector spaces, metric spaces, Hilbert spaces, complex vector

**Recommended Texts:**


**EE-526 DIGITAL DESIGNS WITH Verilog HDL**

**Course Contents**

Introduction, Basic Concepts; Hierarchy and Modeling Structures; Syntax, Lexical Conventions, Data Types, and Memories; Expressions and Simulation Mechanics; Gate Level Modeling; Behavioral and Register Transfer Level Modeling; State Machine Design; Xilinx Synthesizer (ISE); Design and Synthesis of Data path Controllers; Modeling Storage Devices; Architecture of Digital Processors; Using Spartan-3E FPGA Kit with Practical Examples; Debugging Verilog Models

**Recommended Texts:**


**CMS-528 PROJECT MANAGEMENT**

**Course Contents**

Introduction to management principles, Inter-disciplinary and multidisciplinary skill of a project manager; Project management vs. line management; Project life cycle, different phases of a project life cycle, dynamic and static project interfaces, integration and management of project interfaces; Team building for a project; selection of team members, concept of skills inventory and responsibility matrices; Project planning modeling, a five step-planning model, strategic planning techniques, project planning facilitation techniques;
Development of work breakdown structure (WBS) for the project; Project networking techniques; Critical path method (CPM), scheduling, cost and resource utilization techniques; Managing the project change, techniques to manage the scope changes and baseline changes; Project control techniques: formal and informal control, five-step model for project control, status reports an reviews; Earned value management techniques, achievement monitoring and accomplishment monitoring.; Supporting project management, software types, training and administration techniques.

**Recommended Texts**


**EE-530 SPECIAL TOPICS IN SYSTEMS ENGINEERING - I**
This is a course on advanced topics not already covered in the syllabus. The special paper may be conducted as a lecture course or as an independent study course. The topic and contents of the course must be approved by the faculty.

**NE-534 INTRODUCTION TO NUCLEAR ENGINEERING**

**Course Contents**
Role and importance of nuclear energy; Nuclear cross-sections. Reaction rates; Nuclear fission and chain reaction; Criticality conditions; Conversion and breeding, Reactor components and their characteristics; Classification and design features of research, production, and power reactors, Introduction to fast and fusion reactor systems; Different types of fuel cycles; Core and feed-material preparations; Uranium enrichment; Fabrication of fuel; Reprocessing of irradiated fuel; Process waste disposal. Reactor fuel requirements; Burn up studies of nuclear fuels; Radiation units; Standards of radiation protection; Calculation of exposure and dose, Health physics instruments for personal Dosimetry and environmental surveillance, Nuclear instrumentation module used with various radiation detectors.

**References:**

**EE-544 INSTRUMENTATION AND CONTROL OF NUCLEAR REACTORS**

**Course Contents**
Reactor kinetics; Transfer function; Overview of reactor systems; Safety; Outcore sensors; Incore sensors; Process instrumentation; Signal conditioning; Transfer function measurement systems; Control rod drives and indicating systems; Power supplies; Installation of instrumentation systems; Quality assurance and reliability; Protection systems; Instrumentation systems of nuclear power plants.

**Recommended Texts:**

**EE-554 DIGITAL IMAGE PROCESSING**

**Course Contents**
Image processing fundamentals; Digital image enhancement techniques; Digital image enhancement in the Frequency Domain; Digital image
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restoration; Color image processing, Wavelets and multi-resolution processing; Morphological image processing; Image segmentation; Feature extraction

Recommended Texts:


NE-555 NUCLEAR REACTOR ANALYSIS

Course Contents
Neutron slowing-down; Thermal neutron spectra; Neutron diffusion in non-multiplying media; The one speed diffusion model of a nuclear reactor; Criticality calculations for bare and reflected homogeneous systems; Effects of heterogeneity reactor parameters; The multigroup diffusion method; Numerical solution of multigroup diffusion model; Use of computational codes for criticality calculation; The point reactor kinetics model; Temperature and void coefficient of reactivity, Fuel depletion; Fission product poisoning, Control rods; Introduction to neutron transport equation.

Recommended Texts

EE-601 CONTROL SYSTEMS DESIGN-II

Course Contents
Linear Continuous-Time State Space Models, Transformation of dynamical systems into state-space, Similarity Transformations, Transfer Function to State Space Representation, Controllability, reachability and Stabilizability, Observability, reconstructability and Detectability, Canonical Decomposition, Pole-Zero Cancellation and System Properties, Pole Assignment by State Feedback; Design of servo systems; State Observers, Design of regulator system with observers; design of control systems with observers; Quadratic optimal regulator systems; Phase plane plots of linear systems, investigating stability of linear system using Lyapunve techniques, Case studies

Recommended Texts:
5. T. Kailath, Linear Systems, Printice Hall, 1980
EE-602 NONLINEAR CONTROL

Course Contents

Introduction to nonlinear control; nonlinear models and nonlinear phenomena, limit cycles, bifurcation, etc., Type of nonlinearities, describing functions, Phase-Plane Trajectories, Equilibrium points, Stability Definition, Lyapunov stability; Input-output stability; feedback linearization; stability of perturbed systems; feedback control; sliding mode control; Back-stepping; Pacification and Passivity based control; High gain observers.

Recommended Texts:

EE-603 OPTIMAL CONTROL THEORY

Course Contents

State-space representation of physical systems; Selection of a performance measure; The optimal control law; The principle of optimality applied to the optimal control problem; The calculus of variations; Necessary conditions of optimal control; Linear regulator problems; Pontryagin's minimum principle and state inequality constraints; Minimum time and minimum control effort problems; Numerical determination of optimal control by the method of steepest decent and by the method of variation of extremals.

Recommended Texts:

EE-605 ROBUST CONTROL

Course Contents

Introduction of robust control problem; Limitation on performance; Analysis of MIMO control loops; closed loop stability, frequency domain analysis, Exploiting SISO techniques in MIMO control; completely decentralized control, pairing of inputs and outputs, converting MIMO problems to SISO problems. Poles and zeros of multivariable control systems; Internal stability; Nyquist stability and Gershgorin bands; Principal gains for assessment of performance and robustness; Limitation on performance MIMO systems; Signals and systems norms and their use to assess robustness and performance; Representation of uncertainty; Stability and performance robustness; Loop failure and gain variation; LQG method for control design; Youla parameterization; H-infinity Control; Mu analysis and synthesis; Model reduction techniques; LMI based design.

Recommended Texts:

EE-606 ADAPTIVE CONTROL SYSTEMS

Course Contents
Introduction to adaptive control; real time parameter estimation, deterministic self tuning estimators, stochastic and predictive self tuning regulators, model reference and adaptive systems, properties of adaptive systems, stochastic adaptive control, auto tuning, gain scheduling, practical issues and implementation.

Recommended Texts:

EE-607 SYSTEM IDENTIFICATION

Course Contents
Introduction; Overview of identification methods, areas of application, mathematical models of linear dynamic systems and stochastic signals; Identification of non-parametric models in the frequency domain; spectral analysis methods for periodic and non-periodic signals, frequency response measurement with non-periodic signals, frequency response measurement for periodic test signal; Identification of non-parametric models with correlation analysis; correlation analysis with continuous time models, correlation analysis with discrete time models, Identification with parametric models; least squares parameter estimation for static processes, least squares parameter estimation for dynamic processes, modifications of the least squares parameter estimation, Bayes and maximum likelihood methods, parameter estimation for time-variant processes, parameter estimation in closed-loop, Identification with parametric models; parameter estimation for frequency responses, parameter estimation for differential equations and continuous time processes, subspace methods, Identification of multi-variable systems; parameter estimation for MIMO systems, Identification of non-linear systems; parameter estimation for non-linear systems, state and parameter estimation by Kalman filtering.

Recommended Texts:

EE-612 FAULT DIAGNOSIS AND TOLERANT CONTROL

Course Contents
Importance of the subject; some basic concepts; fault, failure, fault detection, fault isolation, fault identification, modeling of faults in technical systems; Classification of fault detection techniques; hardware redundancy based,
signal based, analytical model based, qualitative model based, Residual
generation techniques; observer based approaches, parity space approach,
parameter identification based approach, Residual evaluation and threshold
computation; Norm based methods, statistical methods, integration of norm
based and statistical methods, Integrated design of fault detection systems;
Fault isolation schemes; Fault identification schemes; Fault tolerant control;
architecture, control reconfiguration for sensor and actuator failures, fault
tolerant H1 control, handling of fault recovery transients.

Recommended Texts:

1. Ding S. X., Model-based fault diagnosis Techniques, Design
3. Chen J. and R. Patton R. J., Robust Model-Based Fault Diagnosis
4. Isermann, R., Fault-Diagnosis Applications: Model-Based
   Condition Monitoring: Actuators, Drives, Machinery, Plants,

EE-614 COMPUTER VISION

Course Contents
Basic Optics and Radiometry; Geometric Image Formation; Segmentation: K-
means, EM Clustering, Mean shift, Image Watershed, Active Snakes, Level
Sets, Graph Cuts; Bilateral Filtering; Anisotropic Diffusion; Texture Analysis;
Representation and Description of regions; Shape Analysis; Feature tracking;
Projective Geometry; Camera Calibration; Structure from stereo; Structure
from Motion; Kalman Filtering and Tracking; Image Registration.

Recommended Texts:

1. Szeliski, R., Computer Vision: Algorithms and Applications,
2. Gonzalez, R., and Woods, R. E., Digital Image Processing,
   Prentice Hall, 2008
3. Goshtasby, A., 2-D and 3-D image registration for medical,
   remote sensing, and industrial applications, John Wiley and
   Sons, 2005
4. Trucco, E., and Verri, A., Introductory Techniques for 3-D

EE-615 ADAPTIVE SIGNAL PROCESSING

Course Contents
Introduction to discrete-time signal processing and random processes;
Optimum linear filters: Wiener filter; linear prediction; Kalman filter; Linear
adaptive filters: Steepest-descent algorithm, LMS algorithm and its variants;
Frequency domain adaptive filters; Method of least squares and RLS
algorithm, tracking of time varying systems; Analysis of adaptive algorithms:
learning curve, convergence, stability, excess mean square error, mis-
adjustment; Applications of adaptive signal processing: Adaptive modeling
and system identification, inverse adaptive modeling, deconvolution and
equalization, adaptive interference cancelling; cancelling noise, cancelling periodic interference, cancelling interference in ECG signals, etc.

**Recommended Texts**


**EE-616 INDUSTRIAL DRIVES**

**Course Contents**


**Recommended Texts:**


**EE-618 ROBOT STRUCTURES, SENSING and PERCEPTION**

**Course Contents**

Structures: Introduction to power transmission methods in Robotics; Wheel Vehicles Suspensions and drive trains; tracked vehicles suspensions and drive trains; Walkers, Crawler; Grippers; Sensing and Perception: Tactile Sensors, Inertial Sensors, Ranging Sensors, Vision Sensing and Visual Servoing, Multisensor Data Fusion.

**Recommended Texts:**

Ms. Systems Engineering Curriculum approved in the meeting of Academic Committee held on November 17, 2011


EE-620 Mobile Robot Task Planning

Course Contents
Trajectory and path planning; cell decomposition, roadmaps, potential fields and navigation functions; kinematic and dynamic constraints; holonomic/non-holonomic vehicles’ constraints; behaviour based navigation, representations, architectures and models; evolutionary navigation, conditional planning for uncertain situations and task graphs, probabilistic planning methods; SLAM algorithms; Case Study: Programming in player/stage for different mobile robot mechanisms.

Recommended Texts

EE-625 SPECIAL TOPICS IN SYSTEMS ENGINEERING - II
This is a course on advanced topics not already covered in the syllabus. The special paper may be conducted as a lecture course or as an independent study course. The topic and contents of the course must be approved by the faculty.

EE-697 M.Sc. THESIS RESEARCH
In fourth semester as a subject and fifth semester in full, student will study some system engineering related problem. He may join some on-going research program or initiate a new program in close cooperation with a faculty member. The faculty member will instruct, supervise, and grade the conduct of this study with the student. He is charged with the primary responsibility of reporting the grade based on the evaluation of the performance of the fellows. He may be aided in the process of evaluation by a committee to be appointed by Rector, PIEAS. A report and seminar are to be given by the student before the end of the semester. The nature of the project may be research, development or design may involve experimental or computational work or combination of these. The student shall write a comprehensive report and shall deliver at least one seminar shall also be used in the overall evaluation of the student. Normally this project is to be completed in full time work for one semester. However, if supervisor(s) feel that more time is needed for the satisfactory completion of the project, the duration may be extended beyond the end of semester.