Teaching Scheme and Syllabus

For

Bachelor of Technology

In

Honors in Electronics and Communication Engineering

Department of Electronics Engineering

Sardar Vallabhbhai National Institute of Technology

Honors in Electronics and Communication Engineering

Sr. No.	Semester	Subject	Code	Schema	Credit	Notional hours of Learning (Approx.)
1	IV	Liner Algebra	EC232	3-1-0	04	70
2	V	Probability and Random Processes	EC313	3-1-0	04	70
3	VI	SoC Design	VL314	3-0-2	04	85
4	VII	Advance DSP	EC415	3-0-2	04	85
5	VII	Mini Project	EC417	0-0-4	02	70

EC232: LINEAR ALGEBRA

L	T	P	C
3	1	0	4

1. Course Outcomes:

CO1	Demonstrate an Understanding of Fundamental Concepts in Linear Algebra, Such as Vectors, Matrices, Determinants, and Linear Transformations.
CO2	Apply Different Techniques to Solve Systems of Linear Equations and Analyze the Solution Sets.
CO3	Analyze the Properties of Vector Spaces, Subspaces, and Orthogonality, and Solve Related Problems.
CO4	Compute Eigenvalues and Eigenvectors for a Given Matrix and Interpret Their Significance in Various Applications.
CO5	Synthesize Various Linear Algebra Techniques to Solve Complex, Real-World Problems.

2. Syllabus

INTRODUCTION	**(04 Hours)**
Geometric Interpretation of a Vectors, Addition, Scalar Multiplication and Linear Combinations, Lengths and Dot Products, Matrices, Types of Matrices, Matrix Addition, Scalar Multiplication and Matrix Multiplication.	
LINEAR EQUATIONS	**(06 Hours)**
Vectors and Linear Equations, Elimination, Elimination Using Matrices, Rules for Matrix Operations, Inverse Matrices, LU Factorization, Transpose and Permutations.	
VECTOR SPACE AND SUBSPACES	**(07 Hours)**
Spaces of Vectors, The Null Space, The Rank and Row Reduced Form, The Complete Solution to Ax=b, Independence, Basis and Dimension, Dimensions of the Four Subspaces	
ORTHOGONALITY	**(08 Hours)**
Definition of Orthogonality in Vectors, Orthogonal and Orthonormal Bases, Orthogonality of the Four Subspaces, Projections, Least Squares Approximations, Orthogonal Bases and Gram-Schmidt, Orthogonal Matrices.	
DETERMINANTS	**(06 Hours)**
Introduction to Determinants, Properties of Determinants, Effects of Row and Columns Operations on Determinants, Multiplicative Property of Determinants, Determinants of Some Special Matrices, Permutations and Cofactors, Cramer's Rule, Inverses and Volumes.	
EIGENVALUES AND EIGENVECTORS	**(07 Hours)**
Introduction to Eigenvalues, Relationship Between Eigenvalues and Matrix Trace/Determinants, Diagonalizing a Matrix, Symmetric Matrices, Positive Definite Matrices, Singular Value Decomposition (SVD).	
APPLICATIONS OF LINEAR ALGEBRA	**(07 Hours)**

Dimensionality Reduction using Principal Component Analysis (PCA), Data Compression Using SVD, Fourier Series: Linear Algebra for Functions, Linear Algebra for Statistics and Probability, Solving Least Square Problem in Linear Regression, Applications in Computer Vision like Scaling, Rotation, and Translation of Images using Matrix Multiplication.	
TUTORIALS WILL BE BASED ON THE COVERAGE OF THE ABOVE TOPICS SEPARATELY	**(15 Hours)**
(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3. Bools Recommended

1	Gilbert Strang, Introduction to Linear Algebra, 5th Edition, Wellesley-Cambridge Press, 2016.
2	David C. Lay, Linear Algebra and Its Applications, 5th Edition, Pearson, 2015.
3	Sheldon Axler, Linear Algebra Done Right, 3rd Edition, Springer, 2015.
4	Roger A. Horn, Charles R. Johnson, Matrix Analysis, 2nd Edition, 2012.
5	Kenneth Holfman, Ray Kunze, Linear Algebra, 2nd Edition, 2018.

EC313: PROBABILITY AND RANDOM PROCESSES

L	T	P	C
3	1	0	4

1. Course Outcomes:

CO1	Explain Sample space and events Combinatorics, Joint and conditional probabilities
CO2	Compare CDF, PDF and established a relation between PDF and CDF.
CO3	Classify Stationary, Nonstationary, Strict-Sense and Wide-Sense Stationary Processes
CO4	Analyze Auto covariance, Power Spectral Density, Joint Statistical Averages of Two Random Processes, Crosscorrelation And Crosscovariance, Ergodicity etc.
CO5	Evaluate response of linear systems through random signals though various output parameters.

2. Syllabus

INTRODUCTION TO PROBABILITY THEORY	**(05 Hours)**
Sets, fields, sample space and events, axiomatic definition of probability. Combinatorics, Joint and conditional probabilities, Independence, total probability, Bayes' rule	
RANDOM VARIABLES	**(12 Hours)**
Cumulative Distribution Function, Probability Density Function. Relation Between Probability And Probability Density, Joint Cumulative Distribution And Probability Density, Characteristic functions and moment generating functions, Average Value And Variance Of A Random Variable, Gaussian Probability Density, Error Function, Rayleigh Probability Density,Mean And Variance Of The Sum Of Random Variables, Correlation Between Random Variables, Central Limit Theorem, liner minimum mean square error and orthogonality principle, Chebysev inequality Sequences Of Random Variables, Convergence Of Sequences Of Random Variables. Weak law of large number.	
STOCHASTIC PROCESSES	**(10 Hours)**
Stationary, Nonstationary, Strict-Sense and Wide-Sense Stationary Processes, Gaussian Processes, Poisson Process and the Markov Process.	
EXPECTED VALUES OF A RANDOM PROCESS	**(10 Hours)**
The Mean Value, Autocorrelation, Autocovariance, Power Spectral Density, Joint Statistical Averages of Two Random Processes, Cross-correlation And Cross-covariance, Ergodicity, Mean Square Continuity, Mean Square Derivative And Mean Square Integral Of Stochastic Processes, Ergodic Processes. White noise process and white noise sequence.	
RANDOM PROCESS THROUGH LINEAR SYSTEMS	**(08 Hours)**
Response of Linear Systems to Random Signals, Stationarity of the Output, Autocorrelation and Power Spectral Density of the Output, Examples with White Noise as the Input, Interpretation of the PSD, Bandlimited Random Processes, Weiner Filtering, Optimum Linear Systems, The Kalman Filter.	
TUTORIALS WILL BE BASED ON THE COVERAGE OF THE ABOVE TOPICS SEPARATELY	**(15 Hours)**
(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3. Bools Recommended

1	Papoulis,"Probability, Random Variables And Stochastic Processes", McGraw-Hill,4th Ed, 2017.
2	Alberto Leon-Garcia, Probability, Statistics, and Random Processes for Electrical Engineering, Pearson, 3rd Ed, 2008.
3	Sheldon M. Ross Introduction to Probability Models Academic Press, 2014.
4	Steven Kay, Intuitive Probability and Random Processes using MATLAB, 2006.
5	Vijay K. Rohatgi, A.K. Md. Ehsanes Salehi, An Introduction to Probability and Statistics, Wiley, 2011.

VL314: SOC DESIGN

L	T	P	C
3	0	2	4

1. Course Outcomes:

CO1	Understand and estimate key design metrics and requirements including area, latency, throughput, energy, power.
CO2	Implement both hardware and software solutions, formulate hardware/software trade-offs, and perform hardware/software codesign
CO3	Analyze issues in system-on-chip design associated with Interconnection Structures, performance and power consumption
CO4	Use of SystemC programming and HLS
CO5	Design and optimize a modern System-on-a-Chip

2. Syllabus

SOC DESIGN APPROACH	**(08 Hours)**
Basics of Chips and SoC ICs, SoC Design: SoC CPU/IP Cores; Co-processor; Cache; DRAM Controller, SoC Synthesis, Static Timing Analysis (STA), Design for Testability, Verification, Physical Design	
HARDWARE-SOFTWARE CO-SYNTHESIS	**(09 Hours)**
Partitioning, Cycle Time, Die Area-and-Cost, Power, Area-time-Power Trade-offs and Chip Reliability, Real-time scheduling, hardware acceleration	
VIRTUAL PROTOTYPING AND HLS	**(10 Hours)**
Mapping High-Level Language Applications to Hardware, Transaction-Level Modeling & Electronic System-Level Languages, Hardware Accelerators, Media Instructions, Co-processors, System-Level Design Methodology, High-Level Synthesis (C-to-RTL), Hardware Synthesis and Architecture Techniques, Source-Level Optimizations	
SOC INTERCONNECTION STRUCTURES	**(10 Hours)**
Bus-based Interconnection, Bus protocols: AMBA AXI Bus; AXI4-Stream; IBM Core Connect; Avalon, Interconnection Structures, Network on Chip - NoC Interconnection and NoC Systems, IP interfacing	
PERFORMANCE / POWER ANALYSIS OF SOCS	**(08 Hours)**
System-level modeling and integration, Simulation platform for performance analysis of SoC/MPSoC, Use cases and examples.	
Total Contact Time: = 45 Hours	

3. List of Practical

1	Design of IP using scheduling and binding algorithms for HLS
2	IP interfacing with ARM using Vivado/Vitis on FPGA
3	Designing hardware accelerators/co-processors
4	FPGA prototyping of hardware/software systems

5	Integration of Peripheral with Processor without/with DMA
6	RTL-to-GDS flow for IP
7	Integration of IP with Processor using RTL-to-GDS flow
8	Verification of SoC

4. Bools Recommended

1	Veena Chakravarthi, “A Practical Approach to VLSI System on Chip (SoC) Design-A Comprehensive Guide”, Springer, 2020
2	S. Pascricha and N. Dutt, “On-Chip Communication Architectures, System on Chip Interconnect”, Morgan Kaufmann-Elsevier Publishers, 2008,
3	Keating, M., “The Simple art of SoC design”, Springer, 2011,.
4	P. Schaumont, “A Practical Introduction to Hardware/Software Co-design”, Springer, 2009,
5	Ghenassia, F., “Transaction-level modeling with SystemC: TLM concepts and applications for embedded systems”, Springer, 2010
6	Grotker, T., Liao, S., Martin, G. & Swan, S., “System design with SystemC”, Springer, 2002

EC415: ADVANCE DSP

L	T	P	C
3	0	2	4

1. Course Outcomes:

CO1	Define different type of signals and systems, and analyze different system characteristics therein
CO2	Describe the concept of FIR, IIR, linear prediction filter, power spectrum estimation
CO3	Solve the problem related to different filtering techniques and power spectrum estimation
CO4	Analyze different filtering techniques
CO5	Design different filtering techniques for different signal processing applications

2. Syllabus

REVIEW OF DISCRETE SIGNAL REPRESENTATION AND ANALYSIS	**(06 Hours)**
Continuous and discrete time signals, noise signal, different type of signals, operations of signals: addition, subtraction, multiplication, scaling, magnification, decimation, interpolation, differentiation and integration, static and dynamic system, LTI system, DFT and FFT	
TIME AND FREQUENCY-DOMAIN DESIGN TECHNIQUES FOR IIR AND FIR FILTERS	**(09 Hours)**
FIR And IIR Filter Specifications, FIR Filter Design- Fourier series method and Frequency Sampling Method, Design Of IIR Digital Filters: Butterworth, Chebyshev And Elliptic Approximations, Low Pass, Band Pass, Band Stop And High Pass Filters, Bilinear Transformation Method	
EFFECT OF FINITE REGISTERS LENGTH	**(04 Hours)**
Number Representation, Quantization Error, Round-Off Error, Overflow Error, Limit Cycle, System Noise behaviour, Noise Filtering By LSI System, Noise in a Cascade Of 2nd Order Filter, Stability of Linear Filter	
MULTIRATE SIGNAL PROCESSING	**(05 Hours)**
General Rate-Changing System, Integer-Factor Interpolation and Decimation and Rational-Factor Rate Changing, Efficient Multirate Filter Structures, Over sampling D/As, Perfect-Reconstruction Filter Banks and Quadrature Mirror Filters.	
OPTIMAL FILTERING OF RANDOM SIGNALS	**(08 Hours)**
Innovations Representation of a Stationary Random Process, Prediction, linear prediction: forward and backward methods, Linear prediction based filter analysis, Prediction error, Levinson recursion method for solving Toeplitz system of equations, AR and ARMA Filter, MLE and MAP, LMS and RLS adaptive filters.	
POWER SPECTRUM ESTIMATION/ANALYSIS	**(06 Hours)**
Non-parametric method, Parametric method, periodogram, Eigen analysis for spectral Estimation.	
APPLICATION OF DSP	**(07 Hours)**

Speech signal processing: Time domain processing of speech, methods for extracting the parameters, Filter bank analysis of speech, radar signal processing, musical sound processing, recent applications.	
PRACTICAL WILL BE BASED ON THE COVERAGE OF THE ABOVE TOPICS SEPARATELY	**(30 Hours)**
(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3. List of Practical

1	Write a MATLAB Program to Get Fourth Order Butterworth Filter.
2	Write a MATLAB Program for Interpolation and Decimation.
3	Write a MATLAB Program to Decimate by Factor of Eight in Two Stages.
4	Write a MATLAB Program for Power Spectral Density of Signal with Random Noise and Draw Spectrum of Chirped Signal.
5	Write A MATLAB Program to Plot the Zeros and Poles of System and Comment on Stability.
6	Write A MATLAB Program to Pass Various Sinusoids of Freq. 50 Hz, 200 Hz and 300 Hz Through Band Pass Filter Having Cutoff Freq. Wn = [0.125, 0.275]; Generated Through Kaiser Window. Draw Its Freq. Spectrum and Output in Time Domain.
7	Write A MATLAB Program for Generation of Moving Average Filter Which Is Basic Low Pass Filter.
8	Write A MATLAB Program for Haar Wavelet Signal Decomposition and Reconstruction.
9	Write A MATLAB Program for DFT Filter Bank Realization.
10	Mini Projects.

4. Bools Recommended

1	Salivahanan S, “Digital Signal Processing”, Fourth Edition, Tata McGraw-Hill, 2019.
2	Rabiner L. R. and Gold B., “Theory and Applications of Digital Signal Processing”, First Edition, Prentice Hall, 2007.
3	Oppenheim A. V. and Schafer, “Discrete Time Signal Processing”, Pearson, Third edition, 2014.
4	Proakis John G. and Manolakis D.G., “Digital Signal Processing: Principle, Algorithms and Applications”, Fourth Edition, Pearson, 2006.
5	Kay, Steven M “Fundamentals of statistical signal processing”, Prentice Hall, 1998.
6	L. R. Rabiner and R. W. Schafer, Digital Processing of Speech Signals, Pearson Education India, First Edition, 2003.