IIT Madras BS in Electronic Systems

FOUNDATIONAL LEVEL COURSES

MA1101 Math for Electronics I

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof. Andrew Thangaraj Department of Electrical Engineering ,IIT Madras.

COURSE DESCRIPTION:

- To introduce differential/integral calculus of one variable
- To introduce solutions for a system of linear equations
- To introduce complex numbers.

SYLLABUS:

- **WEEK 1** Introduction, Linear equations Numbers, relations/functions, equations occurring in practical scenarios and applications Cartesian coordinates, Equation of a line in 2D, Linear equations in two variables, Graphing software Solving systems of linear equations by elimination

- **WEEK 2** Functions of one variable, Limits and continuity Functions and graphs, scaling/shifting operations, trigonometric functions, visualizing functions Limit of a function and limit laws, One-sided/two-sided limits, continuity of a function

- **WEEK 3** Differential calculus Tangent line, Derivatives as slope/rate of change, Derivative, Rules/methods for finding derivatives Applications: Increasing/decreasing functions, Extreme values of functions

- **WEEK 4** Integral calculus Area under step functions, Finite sums, Integrals as area under general functions, Limits of finite sums The definite integral, Fundamental theorem of calculus, Transcendental functions (log, exp, inv trig) Rules/methods for finding integrals, Applications: Areas, Volumes, Averages

- **WEEK 5** Ordinary Differential Equations (ODEs) Applications - Capacitor charging, mass-spring, pendulum Types of ODEs, Boundary conditions, Solutions to first-order homogeneous, linear ODEs

- **WEEK 6** Complex numbers Square root of -1, Imaginary unit i, Complex numbers and arithmetic, Geometric representation Complex-valued functions of one real variable, Complex exponentials, Examples of calculus

PRESCRIBED BOOKS:

The following are the suggested books for the course:

- “Thomas’ Calculus (14th edition),” J. R. Hass, C. E. Heil and M. D. Weir, Pearson.

- “Calculus (8th edition),” J. Stewart, CENGAGE Learning.

- “Calculus, Vol 1, 2ed (An Indian Adaptation),” T. M. Apostol, J. Singh and S. Goyal, W**iley.**

CS1101 Introduction To C Programming

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 3-0-2-4

INSTRUCTOR(S):

- Prof. Nitin Chandrachoodan Department of Electrical Engineering, IIT Madras
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COURSE DESCRIPTION:

- "This course is intended as a practical introduction to C programming for electrical engineers. The focus is on gaining experience with writing and debugging programs. At the end of this course, a student should be able to: write, compile and run programs in C, use debugging tools to find and correct errors in programs, use various constructs in C and the standard library of C to implement basic data structures and algorithms

SYLLABUS:

- **WEEK 1** Write, compile, run programs in C, in a Linux environment; debugging tools
- **WEEK 2** Variables, built-in datatypes, operators; Control flow - conditionals, loops
- **WEEK 3** Modularity and functions; variable scope
- **WEEK 4** Input/Output; Files
- **WEEK 5** Pointers, memory, arrays, strings
- **WEEK 6** Multi-dimensional arrays, dynamic memory allocation; issues - memory leaks, management
- **WEEK 7** Standard library and common extensions (math, time etc.)
- **WEEK 8** Implementation concepts: compilation and execution process; heap/stack; runtime and OS interface The course will involve a significant programming component for each step. The evaluation will include live demonstration of coding in instructor-led session

PRESCRIBED BOOKS:

The following are the suggested books for the course:

- “The C programming language”, Kernighan and Ritchie Online references

CS1901 C Programming Laboratory

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 0-0-1-1

FACULTY:

- Prof. Nitin Chandrachoodan, Department of Electrical Engineering, IIT Madras

COURSE DESCRIPTION:

- This laboratory course introduces C programming through hands-on exercises involving program design, coding, compilation, debugging, and execution. Students gain practical experience with fundamental programming constructs, standard C libraries, and problem-solving techniques to develop efficient programs for engineering applications.

SYLLABUS:

- **Week 1:** Computer architecture basics; Memory and computation models; Split memory architecture; Loops, conditions, and branches; Memory–I/O communication; Introduction to programming and C.
- **Week 2:** Number representation; Negative numbers and hexadecimal; Floating-point representation; Character encoding; Instruction encoding; Compilation process; Role of operating systems.
- **Week 3:** Writing first C program; Structure of C programs; Variables; Operators.
- **Week 4:** Structured programming; Control flow in C; Conditional statements in C; Loops in C.
- **Week 5:** Functions and modular programming; Runtime concepts; Recursion; Scope in C.
- **Week 6:** Pointers and memory concepts; Endianness; Alignment; Pointer-variable relationships; Compiler optimizations.
- **Week 7:** Arrays; Pointer arithmetic; Strings in C; String functions.
- **Week 8:** Structures in C; Struct examples; Typedef; Unions; Enums.
- **Week 9:** Memory management; Heap and stack; Dynamic memory allocation; Multidimensional arrays.
- **Week 10:** File handling in C; Text and binary modes; Bit manipulation.
- **Week 11:** Macros in C; Macro examples; Header files; Multifile projects; Compilation process.

EE1101 Electronic Systems Thinking and Circuits

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof. Sankaran Aniruddhan,Department of Electrical Engineering, IIT Madras, Prof. Boby George, ,Department of Electrical Engineering, IIT Madras and Prof. Janakiraman Viraraghavan, Department of Electrical Engineering, IIT Madras

COURSE DESCRIPTION:

- The course is intended to provide an insight into electronics systems that are commonly encountered in daily life centered around sense-computer-communication. The course will begin with a tear down of a laptop and/ or a mobile phone and looking at the various components. The standout component on the board is the battery which naturally leads to an introduction to voltage and finite energy sources. The course will then go on to identify a couple of ICs on the board like the processor, the RF components all connected to the same power source, each drawing its own current which can be used to motivate the idea of KCL. Basic network analysis will be covered as part of the theory to go hand in hand with these topics. Simple experiments will be conducted on a breadboard to demonstrate the theory where applicable. The idea of a microprocessor and memory will be explained with the help of analogies in an abstract manner.

SYLLABUS:

- **WEEK 1** Introduction,Miniaturization of electronic packaging,Mobile teardown,How small can a mobile phone get?,The battery,The charger,Back of the envelope calculations,The resistor,The Theory.

- **WEEK 2** Introduction to "Voltage",Introduction to "Current" and Ohm's Law,Series and parallel connection of voltage and current sources,I-V characteristics of Resistors, voltage and current sources,Nodal Analysis and KCL,Mesh Analysis and KVL,Measurement of simple resistive circuit,Series and parallel connection of resistors,Introduction to capacitors, Introduction to inductors,Capacitance and Inductance measurement

- **WEEK 3** Dial, Talk and Hear,The Microphone,Motor and Generator,The Sinusoid,Energy of time varying signals,Harmonics,Electricity consumption at home

- **WEEK 4** Problem Solving - Getting Started,Problem Solving - Lower and upper bounds ,Problem Solving - More Complex Problems,Problem Solving - Resistive Ladder,Problem Solving - Wheatstone's bridge,Problem Solving - Resistive Cube

- **WEEK 5** Analog Mixer,Resistive Analog Mixer,Analog Mixer : Simulation,Superposition principle,Analog Mixer using superposition,Linear electrical components,Series and parallel resistive networks,Numerical examples on superposition

- **WEEK 6** The Non-Inverting Amplifier,The Inverting Amplifier,Power Conventions ,The RC Step Response - Experiment,The RC Step Response - Theory

- **WEEK 7** Low Pass Filter - Experiment,Low Pass Filter - Theory,High Pass Filter - Analysis,High Pass Filter - Experiment,Band Pass Filter -Design,Band Pass Filter -Experiment,First order analysis: Limitations

- **WEEK 8** Problem Solving - Resistive Analog Mixer ,Problem Solving - Resistive Analog Mixer using superposition,Problem Solving - Superposition - Voltage sources,Problem Solving - Homogeneity Principle,Problem Solving - Power absorbed by circuit elements ,Problem Solving- Superposition - Current / Voltage sources -1,Problem Solving- Superposition - Current / Voltage sources - 2

- **WEEK 9** Analog vs Digital Audio Representations,Time Quantization,Amplitude Quantization,Sample and Hold Circuit,Flash ADC,Charge Sharing,Switched Capacitors,Capacitive Mixer

- **WEEK 10** Laptop Teardown, Binary Number System, Decimal to Binary Number Conversion, Calculating Wave File Size, Analog vs Digital Computing, Digital Compute Blocks, Lab Instructions - 1

- **WEEK 11** Wired Communication - The Experiment,Wired Communication - Inductive Ringing,Wired Communication - Summary,Wireless Communication - The Radio,Wireless Communication - Modulation Techniques,Wireless Communication - Amplitude Modulation,Wireless Communication - Frequency Modulation,Wireless Communication - The Antenna

- **WEEK 12** Problem Solving - LPF Energy,Problem Solving - Current Source and Capacitors,Problem Solving - Current Source, Capacitors, and Resistors,Problem Solving - Switched Capacitors,Problem Solving - Voltage source and Capacitor,Problem Solving - Voltage source, Current source, and Capacitor,Problem Solving - Current sources and Capacitor,,Course Summary

PRESCRIBED BOOKS:

The following are the suggested books for the course:

- William Hayt, Jack Kemerly, and Steven Durbin. Engineering Circuit Analysis. 8th ed. McGraw Hill Education Pvt. Ltd: McGraw Hill Education; August 2013. a. Chapters 1-5 b. Chapters 7-8

- Digital Logic and Computer Design, M. Mano, 2004 a. Chapter 1

- Horowitz P Hill W. The Art of Electronics. 2nd ed. Cambridge England: Cambridge University Press; 1989. Note: Laboratory manual will be provided for the SPICE Lab.

HS1001 English I

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof.Rajesh Kumar,Department of Humanities and Social Sciences,IIT Madras , Ms.Karthika Sathyanathan,Department of Humanities and Social Sciences,IIT Madras, Prof.Shreesh Chaudhary,Department of Humanities and Social Sciences,IIT Madras , Prof. Om Prakash,Department of Humanities and Social Sciences,Gautham Buddha University, Noida

COURSE DESCRIPTION:

- This course aims at achieving fluency and confidence in spoken and written English. This course will use insights from theories of learning and dominant methods of teaching language.

SYLLABUS:

- **Week 1:** Sounds and Words (Vowel and Consonant sounds)
- **Week 2:** Parts of Speech
- **Week 3:** Sentences (Phrases and Idioms)
- **Week 4:** Speaking Skills (Spoken English Preliminaries)
- **Week 5:** Tenses and Agreement in English Sentences
- **Week 6:** Reading Skills (Skimming, Scanning and Comprehension)
- **Week 7:** Listening Skills
- **Week 8:** Aspiration, Word Stress and Syllabification
- **Week 9:** Speaking Skills (Presentation and Group Discussion)
- **Week 10:** Grammar (Common Errors in English) and Writing Skills
- **Week 11:** Writing Skills (Basics of Writing)
- **Week 12:** Writing Skills (Professional Writing)

PRESCRIBED BOOKS:

The following are the suggested books for the course:

- Aarts, Bas (2011). Oxford Modern English Grammar, New York: Oxford University Press
- Murphy, Raymond (2012). English Grammar in Use, New York: Cambridge University Press. 4th Edition
- Krishnaswamy, Subashree and K. Srilata eds. (2007). Short Fiction from South India. Delhi: OUP.

- Dhanavel, S.P. (2010). English and soft skills (V-1). Chennai: Orient Blackswan.

REFERENCES:

- Oxford English Dictionary
- Croft, Sebastian (2018). How to Analyze People: The Ultimate Guide to Speed Reading People Through Proven Psychological Techniques, Body Language Analysis and Personality Types and Patterns (Available on Kindle)
- Malgudi Days: A collection of short-stories (RK Narayan)
- 365 Jataka Tales (Om Books International)
- 365 Panchatantra Stories (Adil Mukesh)
- 365 Tales from Indian Mythology (Om Books International)

EE1104 Electronic Systems Thinking and Circuits Lab

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 0-0-1-1

INSTRUCTOR(S):

- Prof. Sankaran Aniruddhan,Department of Electrical Engineering, IIT Madras, Prof. Boby George, ,Department of Electrical Engineering, IIT Madras and Prof. Janakiraman Viraraghavan, Department of Electrical Engineering, IIT Madras

COURSE DESCRIPTION:

- The course is intended to provide an insight into electronics systems that are commonly encountered in daily life centered around sense-computer-communication. The course will begin with a tear down of a laptop and/ or a mobile phone and looking at the various components. The standout component on the board is the battery which naturally leads to an introduction to voltage and finite energy sources. The course will then go on to identify a couple of ICs on the board like the processor, the RF components all connected to the same power source, each drawing its own current which can be used to motivate the idea of KCL. Basic network analysis will be covered as part of the theory to go hand in hand with these topics. Simple experiments will be conducted on a breadboard to demonstrate the theory where applicable. The idea of a microprocessor and memory will be explained with the help of analogies in an abstract manner.

CS1102 Introduction to the Linux Shell

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-1-5

INSTRUCTOR(S):

- Prof. Gandham Phanikumar,Department of Metallurgical and Materials Engineering, IIT Madras

COURSE DESCRIPTION:

- The course is intended to introduce concepts of Linux-based operating environments. Students should develop familiarity with software tools and concepts required for managing software projects of different types.

SYLLABUS:

- **WEEK 1** Linux OS; kernel vs distribution; command line interaction vs graphical interfaces
- **WEEK 2** Software management; package installation and updating; users, permissions, administration
- **WEEK 3** Shell scripting; variables, IO redirection, pipes, background jobs
- **WEEK 4** Text processing; file handling; interaction with other scripting languages
- **WEEK 5** Software projects and compilation; make and dependency management
- **WEEK 6** Version control; git; web interfaces
- **WEEK 7** Basic networking; DNS; servers, daemons; remote access - secure shell The course will have extensive practical exercises including instructor-led sessions and coding with instructors.

PRESCRIBED BOOKS:

The following are the suggested books for the course:

- “Introduction to Linux - A Hands On Guide”, M. Garrels, The Linux Documentation Project
- “An introduction to Computer Networks”, P. Dordal
- Curated online reference material e SPICE Lab.

CS1902 Linux Systems Laboratory

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 0-0-1-1

FACULTY:

- Prof. Gandham Phanikumar, Department of Metallurgical and Materials Engineering, IIT Madras

COURSE DESCRIPTION:

- This laboratory course introduces Linux-based operating environments through hands-on exercises involving command-line operations, file and process management, shell scripting, and software development tools. The course develops practical skills in using Linux utilities and essential tools for software development, automation, and project management.

SYLLABUS:

- **Week 1:** Linux virtual machine setup; Command-line environment; Basic Linux commands; Linux file system hierarchy.
- **Week 2:** Command-line text editors; Networking commands; Secure Shell (SSH).
- **Week 3:** Combining commands and file handling; Input/output redirection; Software package management; Process management.
- **Week-4:** Pattern matching; Regular expressions; `grep` command.
- **Week 5:** Shell fundamentals; Shell variables; Indexed and associative arrays; Array manipulation; Command substitution (assigning command output to variables).
- **Week 6:** Command-line utilities: `find`, `make`, and archiving tools; Introduction to shell scripting and Bash scripting.
- **Week-7:** Bash scripting: Conditional statements, loop statements, and `case` statements.
- **Week-8:** Automation scripts; Task scheduling using `crontab`; Stream Editor (`sed`) for searching, filtering, and editing text streams and files.
- **Week 9:** AWK: Text processing and data analysis; Regular expressions in AWK; AWK as a programming language.
- **Week 10:** Version control with Git: Workflow, branching, merging, and pull requests; Collaboration and issue management; Hardware management; Shell prompt customization; Storage management.

EE1102 Digital Systems

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof. Janakiraman Viraraghavan,Electrical Engineering Department,IIT Madras
- Prof. Ramprasath S, Department of Electrical Engineering, IIT Madras

COURSE DESCRIPTION:

- The course is intended as an introduction to digital logic and systems. At the end of the course, students should be able to:
- understand and explain digital systems composed of basic combinational and sequential elements
- understand issues with timing and the performance analysis of circuits
- understand the use of finite state machine based controllers and their use in design of complex circuits
- understand the basic operation of a microprocessor in terms of a datapath and programmable control, along with memory interfacing

SYLLABUS:

- **WEEK 1** Digital systems, Boolean algebra, logic gates; truth tables and basic theorems
- **WEEK 2** Number systems; binary, hexadecimal
- **WEEK 3** Hardware description languages; structural and behavioral design
- **WEEK 4** Combinational design; HDL based modular design
- **WEEK 5** Sequential elements; state and timing; timing parameters and analysis;
- **WEEK 6** Finite state machines; sequence detectors and generators; control signal generation
- **WEEK 7** Datapath and Control; simple microprocessor architecture; programmable systems
- **WEEK 8** Basic instruction sets; assembly programming
- **WEEK 9** HDL synthesis; implementing on FPGA

PRESCRIBED BOOKS:

The following are the suggested books for the course:

- Digital Logic and Computer Design, M. Mano, 2004
- Digital Design and Computer Architecture, Harris and Harris, MK 2013 Lab.

EE1103 Electrical and Electronic Circuits

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof. Sankaran Aniruddhan,Department of Electrical Engineering, IIT Madras,
- Prof. Boby George, ,Department of Electrical Engineering, IIT Madras
- Prof. R. S. Ashwin Kumar, Assistant Professor, Electrical Engineering Department, IT Kanpur

COURSE DESCRIPTION:

- At the end of this course, the student should be able to understand and analyze Linear Circuits in the time and frequency domain. 2- and 3-terminal nonlinear devices will be introduced.

SYLLABUS:

- **WEEK 1** Review of: R, C, L, M, independent and dependent sources, Nodal and Mesh Analysis, Thevenin and Norton equivalent; Transient analysis of electrical networks
- **WEEK 2** DC and AC, phasors, complex impedance and admittance
- **WEEK 3** Laplace/frequency domain
- **WEEK 4** frequency response, Bode plots, poles and zeros
- **WEEK 5** RLC circuits, Quality factor
- **WEEK 6** Complex power, 3-phase systems
- **WEEK 7** Linear two port networks and network theorems
- **WEEK 8** Non-linear elements - diodes and transistors

PRESCRIBED BOOKS:

The following are the suggested books for the course:

- Engineering Circuit Analysis, Hayt, Kemmerly and Durbin, 8th Edition, 2013
- MICROELECTRONIC CIRCUITS: THEORY AND APPLICATIONS, Sedra, Smith and Chandorkar, 7th Edition, 2017

EE1105 Electronics Laboratory

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 0-0-3-3

INSTRUCTOR(S):

- Prof. Sankaran Aniruddhan,Department of Electrical Engineering, IIT Madras, Prof. Boby George, ,Department of Electrical Engineering, IIT Madras and Prof. Janakiraman Viraraghavan,Electrical Engineering Department,IIT Madras

COURSE DESCRIPTION:

- Learning various fundamental concepts of electrical and electronic circuits. Learning Outcomes:By the end of this course, students should be able to understand the basic concepts of analog and and digital circuits and apply the same in real world applications.

SYLLABUS:

- **WEEK 1** Two-port networks
- **WEEK 2** Resonant networks, frequency response
- **WEEK 3** Time-domain response of first order systems
- **WEEK 4** Nonlinear device characterization
- **WEEK 5** Logic gates
- **WEEK 6** Functional circuits
- **WEEK 7** Datapath and control circuits
- **WEEK 8** Sequential circuits

CS2101 Embedded C Programming

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof. Nitin Chandrachoodan Department of Electrical Engineering, IIT Madras

COURSE DESCRIPTION:

- This course addresses the use of microcontrollers (uCs) to implement embedded systems. At the end of this course, a student should be able to:
- identify and distinguish types of uCs, their uses, and make design selection decisions
- write, compile, execute, and debug programs on generic uCs
- understand interfacing of peripherals and construction of basic embedded systems involving uCs and external peripheral circuits

SYLLABUS:

- Week 1: Introduction to Embedded Systems and Microcontrollers
- Week 2: Basics of Embedded C Programming
- Week 3: Intermediate STM32 Programming and Architecture
- Week 4: Advanced Peripheral Interfacing
- Week 5: Digital Communication Protocols
- Week 6: Advanced Peripheral Interfacing II
- Week 7: Practice and Problem Solving
- Week 8: Embedded Software Design Patterns and System Architecture
- Week 9: Introduction to Real-Time Operating Systems (RTOS)
- Week 10: Advanced Embedded C Concepts
- Week 11: Development Tools and Debugging Techniques
- Week 12: Safety, Ethics, and Professional Practices

PRESCRIBED BOOKS:

The following are the suggested books for the course:

- Class Notes
- The C Programming Language, Kernighan and Ritchie
- Curated online reference material

CS2901 Embedded C Programming Lab

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 0-0-1-1

INSTRUCTOR(S):

- Prof. Nitin Chandrachoodan Department of Electrical Engineering, IIT Madras

COURSE DESCRIPTION:

- The laboratory complements the Embedded C Programming theory course by providing hands-on experience with modern microcontroller development boards and software tools.

- Students perform practical experiments involving the Hardware Abstraction Layer (HAL), GPIO, communication protocols such as UART, I²C, and SPI, and timers.

- The laboratory also covers testing, debugging, and validation using an integrated development environment (IDE), helping students develop practical embedded systems programming skills.

HS1002 English II

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof.Rajesh Kumar,Department of Humanities and Social Sciences,IIT Madras , Ms.Karthika Sathyanathan,Department of Humanities and Social Sciences,IIT Madras, Prof.Shreesh Chaudhary,Department of Humanities and Social Sciences,IIT Madras , Prof. Om Prakash,Department of Humanities and Social Sciences,Gautham Buddha University, Noida

COURSE DESCRIPTION:

- Focus on achieving greater degree of fluency in functional and conversational English to understand subtle and detailed meaning in conversations and texts through short literary pieces and contextualized content.

SYLLABUS:

- **Week 1:** Patterns in Sentences
- **Week 2:** Patterns in Sentences (Continued)
- **Week 3:** Patterns in Sentences (Continued)
- **Week 4:** Listening Skills
- **Week 5:** Listening Skills (Continued)
- **Week 6:** Speaking Skills
- **Week 7:** Speaking Skills (Continued)
- **Week 8:** Reading Skills
- **Week 9:** Writing Skills
- **Week 10:** Writing Skills (Continued)
- **Week 11:** Social Skills
- **Week 12:** Social Skills (Continued)

DIPLOMA LEVEL COURSES

CS1002 Python Programming

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof. Sudarshan Iyengar,Department of Computer Science and Engineering,IIT Ropar
- Prof. Satyadev Nandakumar, Associate Professor, Department of Computer Science and Engineering, IIT Kanpur

COURSE DESCRIPTION:

- This will be the first formal programming course that students will see in this programme. The goal of this course is to introduce Python programming, which is used throughout the programme, with a basic problem solving and algorithmic flavor.

SYLLABUS:

- Week 1: Introduction to algorithms
- Week-2: Conditionals
- Week-3: Conditionals (Continued)
- Week-4: Iterations and Ranges
- Week-5: Iterations and Ranges (Continued)
- Week-6: Basic Collections in Python
- Week-7: Basic Collections Python(Continued)
- Week-8: Basic Collections Python(Continued)
- Week-9 File Operations
- Week-10: File Operations (Continued)
- Week-11: Module system in python
- Week-12: Basic Pandas and Numpy processing of data

PRESCRIBED BOOKS:

The following are the suggested books for the course:

- Title: Python for Everybody. Author: Charles R. Severance. Publisher: Shroff Publishers. ISBN: 9789352136278
- (The PDF of this book is currently available freely at

http://do1.dr-chuck.com/pythonlearn/EN_us/pythonlearn.pdf)

MA2101 Math for Electronics II

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof. Andrew Thangaraj Department of Electrical Engineering ,IIT Madras.

COURSE DESCRIPTION:

- To introduce infinite sequences/series, first/second-order ordinary differential equations, vectors and multivariable calculus

SYLLABUS:

- **Week 1:** Introduction, Real and complex numbers, Vectors, linear equations and linear combination in R^2, Span of a set of vectors in R^2, Vector spaces and Subspaces, Linear dependent and Independent vectors, Basis and dimension of vector (sub)space in R^2, Change of basis in R^2.

- **Week 2:** Linear Transformations in R^2, Linear Transformation and Basis, Matrix representation of a Linear Transformation,Range, Null, and Rank of a Linear Transformation, Composition of Linear Transformation and Matrix Multiplication,Inverse of a linear transformation, Change of basis.

- **Week 3:** Range and Null space of Composition of Linear transformation in R^2, Linear Operators, Applications of operators, Scaling and rotation, Basic matrix algebra and complex vector space, Eigenvalues, Eigenvectors, Properties of eigenvalues and eigenvectors, Diagonalization of a Matrix, Power of a Matrix.

- **Week 4:** Inner product in R^2 and C^2, Magnitude of a vector, Distance between two vectors, and Angle between vectors, Orthogonal complement or Dual, Inner product as a Linear transformation, Adjoint of an operator, Range and Null of an Operator and its Adjoint, Operations with adjoint, Eigenvalues and Eigenvectors of an operator and its adjoint, Least square fit: Orthogonality principle.

- **Week 5:** Vector spaces in R^n and C^n, Span of vectors, Linear dependence and independence, spanning sets and basis, Linear Transformations (in Higher dimensions), Range and Null of a Linear Transformation, Fundamental theorem of Linear Transformation

- **Week 6:** Matrix Algebra - Addition, Multiplication, Inverse, and Powers, Eigenvalues and eigenvectors, Existence of eigenvalues, Determinants, Algebraic and Geometric multiplicities, Diagonalizability and its applications, Change of Basis, Upper Triangularization, Circular Convolution and Circular Matrix.

- **Week 7:** Inner Product Spaces, Norm of vector, Orthogonal vectors, Orthogonal decomposition, Orthonormal basis and orthonormalization, Gram-schmidt orthonormalization, Orthonormal basis: Properties, Least Square Solutions,Orthogonal Complement and Projections.

- **Week 8:** Operators in Inner product spaces, Adjoint of a linear transformation, Four fundamental spaces, Operators and their adjoints, Eigenvalues and Eigenvectors of operators, Self adjoint operators, Diagonalizability of self adjoint operators

- **Week 9:** Conics in 2D, Quadratic forms and Symmetric matrices, Oscillation modes in system, Correlation and Covariance Matrix, Positive semi-definite matrices, Graph and Adjacency Matrix

- **Week 10:** Circulant Matrices and Fourier Basis, Discrete Fourier Transform (DFT), Normal Operators and Matrices.

- **Week 11:** Sequence and Function spaces, Inner product and Norm in Sequence and Function spaces, Orthonormal basis for Signal spaces, Polynomial Approximations and Projections in Function Spaces, Sinusoids, Projection, Fourier Series, Complex Exponential form of Fourier Series

- **Week 12:**Course Summary

PRESCRIBED BOOKS:

The following are the suggested books for the course:

- "Thomas' Calculus (14th edition)," J. R. Hass, C. E. Heil and M. D. Weir, Pearson.
- "Calculus (8th edition)," J. Stewart, CENGAGE Learning.
- "Calculus, Vol 1 and Vol 2, 2ed (An Indian Adaptation)," T. M. Apostol, J. Singh and S. Goyal, Wiley.
- "Advanced Engineering Mathematics," E. Kreyszig, Wiley.
- "Linear Algebra and its Applications," G. Strang, CENGAGE Learning

EE2101 Signals and Systems

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof. Lakshmi Narasimhan Theagarajan, Department Of Electrical Engineering, IIT Madras

COURSE DESCRIPTION:

- At the end of this course, the student should be able to:Understand and apply the concepts about linear time-invariant (LTI) systems,Understand and apply Fourier Series representation of periodic continuous-time signals,understand and apply Fourier Transform representation of periodic and aperiodic continuous-time signals,Apply Laplace transforms to analyze LTI Systems

SYLLABUS:

- **WEEK 1** Introduction to signals --- continuous-time, discrete-time, Analog, Digital, Signal representation and analysis, Manipulation of signals (Time shifting and scaling)

- **WEEK 2** Adding and subtracting signals, complex-valued signals, phasors

- **WEEK 3** Even and Odd symmetry, Orthogonal signals, even-odd signals, conjugate symmetry, periodicity, manipulation of periodic signals, Energy and Power of signals

- **WEEK 4** Dirac delta signal, energy signal, power signal, time scaling of energy and power signals

- **WEEK 5** Introduction to systems and their properties --- causal, memory, Invertibility, stability, Time invariance, Linear, LTI systems, Convolution

- **WEEK 6** Properties of convolution, convolution with Dirac Delta, LTI system properties, Unit step response of LTI systems

- **WEEK 7** Fourier Analysis, Fourier series and properties

- **WEEK 8** Parseval's theorem for Fourier series, Dirchilet's conditions for Fourier series

- **WEEK 9** Fourier Transform, The Uncertainty principle, properties of Fourier Transform, Symmetry in Fourier Transform, Duality of Fourier Transform

- **WEEK 10** Fourier transform in LTI systems, Idea Low pass filter, Fourier transform of step signal and periodic signals, Fourier Transform for circuit analysis

- **WEEK 11** Laplace Transform, Region of Convergence, Pole-Zero plots, Bode Plot

- **WEEK 12** Properties of Laplace Transform, Initial and Final Value Theorem, Laplace Transform in Circuit Analysis

PRESCRIBED BOOKS:

The following are the suggested books for the course:

- Signals and Systems: Oppenheim, Willsky and Nawab (2nd Edn).

- Principles of Linear Systems and Signals: B.P. Lathi (2nd Edn).

EE2102 Analog Electronic Systems

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof. Shanthi Pavan,Department of Electrical Engineering,IIT Madras and Dr. Sundararajan Krishnan, Founder and CEO of Aptener Mechatronics Private Limited

COURSE DESCRIPTION:

- Basics of operational amplifier, op-amp based building blocks, linear and nonlinear system, feedback theory, negative/positive feedback, stability criterion, bode plot with gain and phase margin, compensation, passive and active-RC analog filters, RLC filters, voltage and current regulators, AC coupling input and output and oscillators.

SYLLABUS:

- **Week 1**:Introduction to Analog Electronics, Introduction of Feedback Circuit, Concept of Negative Feedback, Introduction to Operational Amplifier, Non Inverting Amplifier Gain
- **Week 2**:Operational Amplifier as VCVS, Operational Amplifier as CCVS, Op-Amp as a Differential Circuit, Op-amp as Current Source
- **Week 3**:Single Supply Operation of Op-Amp, Dual Supply Operation of Op-Amp and Coupling Capacitor, Coupling Capacitor and their Consideration, Offset Voltage of Op-Amp, Output Resistance of Op-Amp.
- **Week 4**:Analog to Digital Converter, Bandgap Voltage Reference Principle, Op-Amp Diode implementation of a bandgap reference, Introduction to Positive Feedback, Schmitt Trigger, Basic Integrator
- **Week 5**: Filter, First Order Low Pass Filter, First Order High Pass Filter, Second Order Filter Pole Locations, Magnitude Response of Second order LPF
- **Week 6**: Second Order Band Pass Filter , Second Order Low Pass Filter, Second Order Filter, Input Offset Current Compensation
- **Week 7**: Two Stage Forward Amplifier, Two Stage Forward Amplifier, Third Order Forward Amplifier, Bode Plot of Third Order Forward Amplifier, Bode Plot of Third Order Forward Amplifier
- **Week 8**: Introduction of Bluetooth Headset, Block Diagram of Bluetooth Headset, Connectivity Subsystem, Audio Subsystem, Power Management Subsystem, Charging Subsystem, LED Subsystem, Sensor Subsystem, End User Consideration
- **Week 9**: Charging Subsystem Consideration, Amplifier design for Charging Subsystem, Battery Charging Profile, Different Types of Current, LiPo Battery Charger circuit and charging Module
- **Week 10**: Voltage Regulators - Linear Regulators - Basic Principles and IC Selection
- **Week 11**:Voltage Regulators - Switching Regulators - Basic Principles and IC Selection
- **Week 12**:Audio Amplifiers - Types of Amplifiers - Basic Principles and Efficiency Calculation

PRESCRIBED BOOKS:

The following are the suggested books for the course:

- Microelectronic Circuits: Theory and Applications (International Version) Paperback – 11 Mar 2013 by A. Sedra, K.

- Smith, A. Chandorkar Publisher: Oxford; Sixth edition (11 March 2013)ISBN-13: 978-0198089131

EE2104 Analog Electronics Laboratory

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 0-0-3-3

INSTRUCTOR(S):

- Prof. Saurabh Saxena,Department of Electrical Engineering, IIT Madras, Prof. Nagendra, ,Department of Electrical Engineering, IIT Madras and Prof. Janakiraman Viraraghavan,Electrical Engineering Department,IIT Madras

COURSE DESCRIPTION:

- Learning various fundamental concepts of electrical and electronic circuits. Learning Outcomes:By the end of this course, students should be able to understand the basic concepts of analog and and digital circuits and apply the same in real world applications.

SYLLABUS:

Module 1 : Ramp Generator

Module 2 : Single Ended- to differential input converter and PWM Modulator

Module 3 : H-Bridge Driver and Integration

Module 4 : Bandpass Filter

Module 5 : Adder

Module 6 : Top Level Integration

EE3101 Digital Signal Processing

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-1-5

INSTRUCTOR(S):

- Prof. Dr. R. David Koilpilla, Department Of Electrical Engineering,IIT Madras

COURSE DESCRIPTION:

To teach the fundamentals of Digital Signal Processing

SYLLABUS:

- **WEEK 1** Review of Signals and Systems: Discrete time complex exponentials and other basic signals—scaling of the independent axis and differences from its continuous-time counterpart—system properties (linearity, time-invariance, memory, causality, BIBO stability)—LTI systems described by linear constant coefficient difference equations (LCCDE)—impulse response and convolution

- **WEEK 2** Review of Signals and Systems: Discrete time complex exponentials and other basic signals—scaling of the independent axis and differences from its continuous-time counterpart—system properties (linearity, time-invariance, memory, causality, BIBO stability)—LTI systems described by linear constant coefficient difference equations (LCCDE)—impulse response and convolution

- **WEEK 3** Sampling: Impulse train sampling—relationship between impulse trained sampled continuous-time signal spectrum and the DTFT of its discrete-time counterpart—scaling of the frequency axis—relationship between true frequency and digital frequency—reconstruction through sinc interpolation—aliasing—effect of sampling at a discontinuous point—relationship between analog and digital sinc—effects of oversampling—discrete-time processing of continuous-time signals

- **WEEK 4** Sampling: Impulse train sampling—relationship between impulse trained sampled continuous-time signal spectrum and the DTFT of its discrete-time counterpart—scaling of the frequency axis—relationship between true frequency and digital frequency—reconstruction through sinc interpolation—aliasing—effect of sampling at a discontinuous point—relationship between analog and digital sinc—effects of oversampling—discrete-time processing of continuous-time signals

- **WEEK 5** Discrete-Time Fourier Transform (DTFT): Complex exponentials as eigensignals of LTI systems—DTFT definition—inversion formula—properties—relationship to continuous-time Fourier series (CTFS)

- **WEEK 6** Discrete-Time Fourier Transform (DTFT): Complex exponentials as eigensignals of LTI systems—DTFT definition—inversion formula—properties—relationship to continuous-time Fourier series (CTFS)

- **WEEK 7** Z-Transform: Generalized complex exponentials as eigensignals of LTI systems—z-transform definition—region of convergence (RoC)—properties of RoC—properties of the z-transform—inverse z-transform methods (partial fraction expansion, power series method,

contour integral approach)—pole-zero plots—time-domain responses of simple pole-zero plots—RoC implications of causality and stability

- **WEEK 8** Z-Transform: Generalized complex exponentials as eigensignals of LTI systems—z-transform definition—region of convergence (RoC)—properties of RoC—properties of the z-transform—inverse z-transform methods (partial fraction expansion, power series method, contour integral approach)—pole-zero plots—time-domain responses of simple pole-zero plots—RoC implications of causality and stability

- **WEEK 9** Frequency Domain Analysis of LTI Systems: Frequency response of systems with rational transfer function—definitions of magnitude and phase response—geometric method of frequency response evaluation from pole-zero plot—frequency response of single complex zero/pole—frequency response of simple configurations (second order resonator, notch filter, averaging filter, comb filter, allpass systems)—phase response—definition of principal phase—zero-phase response—group delay—phase response of single complex zero/pole—extension to higher order systems—effect of a unit circle zero on the phase response—zero-phase response representation of systems with rational transfer function—minimum phase and allpass systems—constant group delay and its consequences—generalized linear phase—conditions that have to be met for a filter to have generalized linear phase—four types of linear phase FIR filters—on the zero locations of a linear phase FIR filter—constrained zeros at z = 1 and at z = -1 and their implications on choice of filters Type I through Type IV when designing filters—frequency response expressions for Type I through Type IV filters

- **WEEK 10** Frequency Domain Analysis of LTI Systems: Frequency response of systems with rational transfer function—definitions of magnitude and phase response—geometric method of frequency response evaluation from pole-zero plot—frequency response of single complex zero/pole—frequency response of simple configurations (second order resonator, notch filter, averaging filter, comb filter, allpass systems)—phase response—definition of principal phase—zero-phase response—group delay—phase response of single complex zero/pole—extension to higher order systems—effect of a unit circle zero on the phase response—zero-phase response representation of systems with rational transfer function—minimum phase and allpass systems—constant group delay and its consequences—generalized linear phase—conditions that have to be met for a filter to have generalized linear phase—four types of linear phase FIR filters—on the zero locations of a linear phase FIR filter—constrained zeros at z = 1 and at z = -1 and their implications on choice of filters Type I through Type IV when designing filters—frequency response expressions for Type I through Type IV filters

- **WEEK 11** Discrete Fourier Transform (DFT): Definition of the DFT and inverse DFT—relationship to discrete-time Fourier series—matrix representation—DFT as the samples of the DTFT and the implied periodicity of the time-domain signal—recovering the DTFT from the DFT—circular shift of signal and the "index mod N" concept—properties of the DFT—circular convolution and its relationship with linear convolution—effect of zero padding—introduction to the Fast Fourier Transform (FFT) algorithm—decimation-in-time and decimation-in-frequency algorithms.

- **WEEK 12** Discrete Fourier Transform (DFT): Definition of the DFT and inverse DFT—relationship to discrete-time Fourier series—matrix representation—DFT as the samples of the DTFT and the implied periodicity of the time-domain signal—recovering the DTFT from the DFT—circular shift of signal and the "index mod N" concept—properties of the DFT—circular convolution and its relationship with linear convolution—effect of zero padding—introduction to the Fast Fourier Transform (FFT) algorithm—decimation-in-time and decimation-in-frequency algorithms.

PRESCRIBED BOOKS:

The following are the suggested books for the course:

- Discrete-Time Signal Processing by Alan V. Oppenheim and Ronald W. Schafer, 3rd edition, 2010, Prentice Hall, Upper Saddle River, NJ.
- Digital Signal Processing by Tarun K Rawat, 2nd Edition, 2015, Oxford University Press.
- Digital Signal Processing by John G. Proakis and Dimitris K. Manolakis, 4th edition, 2007, Prentice Hall, Upper Saddle River, NJ.
- Digital Signal Processing by Sanjit Mitra, 4th edition, 2011, McGraw-Hill, New York, NY.

EE2103 Digital System Design

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof. Nitin Chandrachoodan Department of Electrical Engineering, IIT Madras

Objectives:

This course is an advanced follow-up to the basic digital system design course. It is designed to teach concepts of larger digital systems and their design considerations, centered around the use of FPGAs for implementing large systems. The course aims to bridge the gap between theoretical knowledge and practical implementation in digital system design.

Course Contents:

- **Module 1:** Foundations of HDL and FPGA Design: Introduction to Verilog HDL, FPGA concepts, and basic digital design techniques.
- **Module 2:** Advanced Verilog and Design Techniques: Finite State Machines, advanced Verilog constructs, and timing analysis basics.
- **Module 3:** CPU Design: Designing a basic CPU architecture, including datapath and control unit, using Verilog.
- **Module 4:** System Integration: Memory systems, peripheral interfaces, and bus protocols for digital system integration.
- **Module 5:** Advanced Topics and System Design: Advanced timing analysis, design for testability, and debugging techniques.
- **Module 6:** System-on-Chip Concepts: Overview of SoC architectures, IP cores, and system-level design considerations.

Text Books:

1. "Digital Design and Computer Architecture" by David Harris and Sarah Harris, Morgan-Kaufmann
   2012

Reference Books:

1. "Advanced Digital Design with the Verilog HDL" by Michael D. Ciletti, Pearson 2017

EE3103 Sensors and Applications

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof. Boby George,Department of Electrical Engineering, IIT Madras, Prof.Chinthaka, Department of Electrical Engineering, IIT Madras

Objectives:

The course aims to provide students with a comprehensive understanding of various sensor technologies, their operating principles, and key characteristics. It also focuses on interface electronics and practical applications, preparing students to design and implement sensor-based systems in automotive, consumer, power, and medical fields.

Course Contents:

- **Module 1:**
  - Sensors:
    - Types and characteristics.
- **Module 2:**
  - Mechanical and acoustic sensors:
    - metallic, thin-film and semiconductor strain gauges, silicon pressure sensors, accelerometers, displacement transducers, piezo junction devices, piezoelectric field-effect transducers, surface acoustic wave devices, ultrasonic based sensors, flow sensors.
- **Module 3:**
  - Magnetic and Electric field sensors:
    - Sensors based on variable magnetic coupling, search coil, magneto resistors, Hall-effect devices, integrated Hall devices, fluxgate sensors, solid-state read and write heads, electrostatic sensors and applications.
- **Module 4:**
  - Light-sensitive sensors:
    - photovoltaic diodes, photoconductors, photodiodes, phototransistors, positron-sensitive photodetectors, opto-isolators, photodiode arrays, charge-coupled devices, fiber-optic sensor technologies and applications.
- **Module 5:**
  - Thermal sensors:
    - Platinum resistors, thermistors, silicon transistor thermometers, integrated temperature transducers, thermocouples.
- **Module 6:**
  - Interface electronics:
    - Noise analysis of interface circuits, electronic circuits designed to interface directly with the sensing elements, linearization, A/D conversion, temperature compensation.

        - Current, frequency, period or pulse-width modulation conversion, microcomputer/microcontroller interfacing.

- **Module 7:**
    - Sensor systems and applications:
        - Integrated sensors-actuators, microsystems, sensor buses, multiple-sensor systems, sensor networks and automotive, consumer, power, medical measurement systems.

Text Books:

1. Pallas-Areny Ramon, John G. Webster. Sensors and signal conditioning. New York: Wiley, 2001.

Reference Books:

1. De Silva, Clarence W. Sensors and actuators: Engineering system instrumentation. CRC Press, 2015.
2. Ripka, Pavel, Alois Tipek, eds. Modern sensors handbook. John Wiley & Sons, 2013.
3. Khazan, Alexander D. Transducers and their elements: design and application. Prentice Hall, 1994.
4. Fraden, Jacob. Handbook of modern sensors: physics, designs, and applications. Springer Science & Business Media, 2004.
5. Tumanski, Slawomir. Handbook of magnetic measurements. CRC Press, 2016.

EE3104 Sensors and Applications Lab

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 0-0-3-3

INSTRUCTOR(S):

- Prof. Boby George, ,Department of Electrical Engineering, IIT Madras

COURSE DESCRIPTION:

- A significant source of data sets and problems for data scientists will come from the business domain. This course provides a basic understanding of how businesses are organised and run from a data perspective.

SYLLABUS:

- Experiment No 1:
  Design and Analysis of an Instrumentation Amplifier (INA) Precision Signal Conditioning: Design and implement a 3-opamp Instrumentation Amplifier (INA) tuned for high Common-Mode Rejection Ratio (CMRR) to isolate and amplify weak differential signals.

- Experiment No 2:
  Temperature Sensor Unit Using NTC Thermistor Environmental Sensing: Design a temperature monitoring unit using an NTC thermistor, and utilizing hardware linearization to output proportional voltage.

- Experiment No 3:
  An Electronic Compass Using Hall Effect Sensors: Build an electronic compass using orthogonally mounted Hall Effect sensors to compute real-time directional heading angles.

- Experiment No 4:
  Human Activity Recognition Using Smartphone Accelerometer: Log 3-axis smartphone accelerometer data and process it using Python/MATLAB. Develop custom step-detection algorithms utilizing Simple Moving Average (SMA) filters and peak-detection logic to classify physical activities.

- Experiment No 5:
  Phase Measurement System To design, implement and test a phase measurement scheme.

EE3102 Control Engineering

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof. Ramkrishna Pasumarthy ,Department of Electrical Engineering, IIT Madras ,
  Prof.Chinthaka, Department of Electrical Engineering, IIT Madras

Objectives:

The course aims to provide hands-on experience with various sensor technologies, including temperature sensors, optical sensors, and accelerometers, while emphasizing signal processing and microcontroller interfacing. Students will design experiments, implement electronic systems, and develop algorithms for sensor-based applications, preparing them for practical challenges in sensor integration and analysis.

Course Contents:

- **Module 1 :** Temperature sensor based on (a) Resistive Temperature Detector (RTD), and (b) Thermistor.

- **Module 2 :** Linearization of Thermistor output, using (a) electronic circuit and (b) using a suitable algorithm

- **Module 3 :** Photoplethysmography (PPG): Obtain the PPG waveform at the red wavelength using a suitable optical source and detector, and electronic circuit. Digitize the signal using a microcontroller and transfer it to a PC using RS232/Bluetooth.

- **Module 4 :** In the PPG experiment, (a) Introduce a feedback mechanism to normalize the DC component of the signal across the users. (b) Write a program to filter the PPG wave to reduce the noise, estimate the heart rate (HR), and display it. Compare the HR with manual counting.

- **Module 5 :** Record acceleration data from a cell phone by keeping the cell phone in the pocket (a) while walking on a flat floor, (b) while climbing down a staircase, and (c) climbing up a staircase. Transfer the data to a PC, write an algorithm, and then create a program to detect these activities from the accelerometer data.

- **Module 6 :** Develop a microcontroller-based unit to measure capacitance using the timer, digital port, and comparator of it. Additional passive components can be used. Estimate the resolution and identify the source of errors. Demo its application as a non-contact touch switch.

Text Books:

1. "Modern Control Engineering" by Katsuhiko Ogata
2. "Feedback Control of Dynamic Systems" by Gene F. Franklin, J. Da Powell, and Abbas Emami-Naeini

EE3999 Electronics System Project

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 0-0-0-3

INSTRUCTOR(S):

- Prof. Sankaran Aniruddhan , Prof. Boby George , Prof. Janakiraman Viraraghavan , Prof. Lakshmi Narasimhan Theagarajan

Objectives:

The Electronic Systems Project is a hands-on, application-oriented project designed to give students real-world experience in solving engineering problems under the guidance of expert faculty from IIT Madras. This two-month-long project is a crucial part of the degree-level curriculum and blends both online and in-person modes of engagement. Students will work in small teams or individually on projects guided by professors, focusing on areas such as embedded systems, signal processing, control systems, IoT, and more. The project begins with online mentoring and development, followed by an intensive two-week on-campus component at IIT Madras, where students can prototype, test, and present their solutions using lab infrastructure. This initiative not only builds technical depth but also hones critical skills like teamwork, communication, and project management.

EE4999 Signal Processing project

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 0-0-0-3

INSTRUCTOR(S):

- Prof. Sankaran Aniruddhan , Prof. Boby George , Prof. Janakiraman Viraraghavan , Prof. Lakshmi Narasimhan Theagarajan

Objectives:

The Signal Processing Project is a software-based, application-oriented initiative designed to help students apply advanced concepts of **digital signal processing (DSP)** and **signals and systems** to real-world challenges. This two-month-long project, guided by IIT Madras faculty, enables students to design, implement, and test algorithms in domains such as audio, speech, biomedical, communication, and image signals using industry-standard tools and programming platforms. Students will engage in structured online mentoring followed by project development, culminating in demonstrations that emphasize technical accuracy, efficiency, and innovation. In addition to strengthening DSP expertise, the project fosters skills in research, documentation, teamwork, and effective communication—preparing students for higher studies and industry applications in signal processing.

DEGREE LEVEL COURSES

EE3105 Electromagnetic Fields and Transmission Lines

Objectives:

This course will provide students with a deep understanding of the behavior of transmission lines and their connection to electromagnetic fields. The course also covers the fundamentals of Maxwell's equations, their relation to transmission line models, and the transition to understanding electromagnetic wave propagation in different media, preparing students for applications in wireless communications, power transmission, and signal analysis.

Course Contents:

- **Module 1:**
  - Introduction:
    - The importance of electromagnetic fields and their applications in real-world scenarios, like wireless communications, antennas, and power transmission.

- **Module 2:**
  - Lossless Transmission Lines:
    - Equivalent circuit with LC ladder, Notion of finite velocity and finite transit time, Telegrapher’s equations, Characteristic Resistance, Introduction to Finite Difference method, Matlab based solution to Telegrapher’s equations, Open circuit and Short circuit boundary conditions,
    - Decoupled telegrapher’s equations - The Laplace and Wave equation, difference between statics and dynamics, Matlab based solution to Laplace, Poisson and Wave equations, Uniqueness theorem, The meaning of Dirichlet and Neumann boundary conditions, The finite difference time domain method,
    - Reflection coefficient - Voltage and Current, Meaning of positive and negative characteristic resistance, Bounce diagram and evolution of voltage at a point, Steady state sinusoidal solution to Telegrapher’s equations, Standing waves and VSWR,The impulse response with Matlab simulations, Time domain reflectometry for gauging faults in transmission lines,
    - Transmission line interconnections - Effects on velocity, wavelength and reflection/transmission coefficients, The absorbing boundary condition to approximate infinite length transmission lines

- **Module 3:**
  - Lossy transmission lines:
    - Introduction of R and G in LC ladder at correct places, Telegrapher’s equations modified for loss, Characteristic Impedance, Matlab based exercises to analyze Attenuation in a transmission line,
    - Negative resistance and negative conductance as circuit equivalents for amplifying a signal for repeaters, Attenuation constant, Phase constant and Propagation constant, Matlab exercise to analyze attenuation and amplification,

        - Reflection coefficient and the voltage standing wave ratio in lossy line, Impedance matching basics, Introduction to Smith's charts, Matlab exercises to create Smith's chart,
        - Impedance matching techniques using computer exercises : theory and practice, Losses as a function of signal frequency and the need for cutting the wires for wireless transmission
- **Module 4:**
    - Maxwell's equations and reduction to transmission line model:
        - Equivalence of Curl equations to Telegrapher's equations in one dimension, Gauss's laws as boundary conditions, Equivalence of electromagnetic wave equation and decoupled TL wave equation, Matlab exercises to solve Maxwell's equations,
        - The Perfect Electric Conductor and Perfect Magnetic conductor and equivalence to Short circuit and Open circuit boundary conditions, Definition of Electric field reflection coefficient and transmission coefficient, The characteristic impedance in a wireless medium and the physical limits, Electromagnetic steady state response in a lossless medium,
        - Types of media - Good dielectric, Poor dielectric, Neither dielectric nor conductive, Poor conductor, good conductor, The standing wave ratio, Definition of Power and Poynting vector, Matlab based exercises to visualize and calculate quantities, The plane wave and its characteristics.
        - The right handed triad with electric field, magnetic field and Poynting vector.

- **Module 5:**
    - Maxwell's equations and deviations from transmission line model:
        - Non-confinement of signals due to no defined path as in transmission lines, The Divergence of fields, Huygen's principle and construction of wavefronts by superposition, Parallel and Perpendicular polarizations,
        - Temporal patterns in fields - Linear, elliptical, circular and random polarizations as deviations from Transmission line model, Concept of interfaces and Impedance mismatches with angles in Parallel and Perpendicular polarizations, Normal and Oblique incidence,
        - The difficulty in impedance matching in a wireless system and the Brewster's angle, Types of interfaces - Dielectric/Dielectric, Dielectric/Conductor and the signal travel across interfaces, Matlab exercises to visualize a 2D signal propagation as opposed to a 1D signal propagation in transmission lines

- **Module 6:**
    - Signals in bounded media:
        - Standing waves in 2D and 3D space, Introduction to modes, Parallel plate waveguide, Rectangular waveguide, Group vs Phase velocity, The microwave cavity, Applications using Matlab exercises - Routing, Study of waveguide bends, 1:2 and 1:4 splitters and combiners, Resonant couplers, Resonators, Applications involving refractive index sensing

Text Books:

1. Ramo, Whinnery and Van Duzer, "Fields and Waves in Communication Electronics," 3rd Ed, John Wiley and Sons (Asia) Pvt. Ltd., 2002.
2. Hayt, William, and John Buck. "Engineering electromagnetics.", 2012.

Reference Books:

1. Jackson, J.D., "Classical Electrodynamics," 2nd ed., Wiley Eastern Pvt. Ltd., New York, 1975.

EE3102 Embedded Linux and FPGAs

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof. Nitin Chandrachoodan Department of Electrical Engineering, IIT Madras

Objectives:

This course introduces students to the design and implementation of embedded systems using FPGA SoC hybrid platforms, focusing on Zynq-based systems. Students will learn to develop custom FPGA IP cores, integrate them with Linux running on the SoC, and optimize hardware-software co-design for embedded applications. Special emphasis is placed on FPGA-accelerated computing for enhanced system performance.

Course Contents:

- **Module 1 :** Introduction to FPGA-SoC Hybrid Systems: Overview of Zynq architecture, PS-PL communication interfaces, and introduction to development tools.
- **Module 2 :** Advanced FPGA Design Techniques: High-level synthesis (HLS) for IP core development, AXI interface and protocol, and implementation of custom IP cores.
- **Module 3 :** Linux on FPGA-SoC systems like Zynq: Linux boot process and customization, Device Tree concepts, writing Linux device drivers for custom IP.
- **Module 4 :** FPGA-Accelerated Computing: Principles of hardware acceleration, identifying acceleration opportunities, computation offloading to FPGA fabric, optimizing data transfer between PS and PL, DMA transfers, parallel processing techniques. Case studies in topics such as image processing, signal processing, and machine learning acceleration.
- **Module 5 :** Performance Analysis and Optimization: Profiling and benchmarking tools and techniques, bottleneck identification, optimization strategies for accelerators.
- **Module 6 :** Real-time Systems and Hardware-Software Co-design: Real-time constraints in embedded systems, algorithm partitioning between PS and PL, co-simulation and debugging techniques for hybrid systems.
- **Module 7 :** Advanced Linux and System Integration: Developing custom Linux modules and drivers, Userspace I/O (UIO) drivers, and system-level optimization techniques for Zynq-based platforms.

Text Books:

1. “The Zynq Book: Embedded Processing with the ARM Cortex-A9 on the Xilinx Zynq-7000 All Programmable SoC” by Louise H. Crockett et al, Strathclyde Academic Publishers (Free PDF download from official site available).
2. “FPGA-based Implementation of Signal Processing Systems” by Roger Woods et al., Wiley, 2017

Reference Books:

1. “Parallel Programming for FPGAs”, Kastner et al., 2018. E-Book published on http://arXiv/1805.03648 • “Embedded SoPC Design with Nios II Processor and Verilog Examples” by Pong P. Chu, 2012 • “Linux Device Drivers” by Jonathan Corbet, Alessandro Rubini, and Greg Kroah-Hartman, E-book: https://lwn.net/Kernel/LDD3/

EE4102 Electronic Product Design

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

Objectives:

The course aims to provide a comprehensive understanding of electronic product design, with a focus on embedded systems. It integrates simulation tools (SPICE), CAD tools (KiCAD), design philosophy, testing, and EMI/EMC considerations to enable students to design, simulate, and troubleshoot electronic products in real-world applications.

Course Contents:

- Module 1 : Rectifiers, protection circuits, heat sink design, and design of Linear Regulators and DC-DC converters (Buck/Boost/Flyback).
- Module 2: Design Base Driver and Gate Driver Circuits for BJTs and MOSFETs respectively. Design of Snubber circuits, and basics of Pulse Width Modulation (PWM).
- Module 3: Magnetics design (inductors and Transformers).
- Module 4: Analog Signal Processing (Design of Op-Amp Circuits and error budgeting, Anti-Aliasing filters, and 4-20 mA current transmission.)
- Module 5: Discrete Essentials, Digital Control (PID), Micro-controller Coding, and DC motor control (Root Locus design)

Text Books:

1. "The Art of Electronics" by Paul Horowitz and Winfield Hill;3rd ed., 2015

Reference Books:

1. "Hardware/Software Co-Design: Principles and Practice" by Jørgen Staunstrup and Wayne Wolf.,1997
2. "PCB Design Tutorial" by David L. Jones.,2004
3. "Circuit Simulation with SPICE OPUS: Theory and Practice" by Tadej Tuma and Árpád Büki.,2009 ed; 2009
4. "Practical Electronics for Inventors" by Paul Scherz and Simon Monk; 4th ed., 2016

BSGN3001Strategies for Professional Growth

INSTRUCTOR(S):

- Prof. Sivakumar M S, Department of Applied Mechanics, IIT Madras
- Prasanna G, Guest Faculty, IIT Madras
- Kartic Vaidyanathan, Guest Faculty, IIT Madras
- Lt Col Jayakumar, Guest Faculty & Consultant, IIT Madras
- Shiva Subramaniam, Guest Faculty, IIT Madras
- Prof. Prathap Haridoss, Department of Metallurgical and Materials Engineering, IIT Madras
- Senthil A V, Certified Financial Planner

COURSE DESCRIPTION:

- The course titled, 'Strategies for Professional Growth' prepares students for corporate life and to be global citizens and provides an opportunity to develop an all-around personality that would help future personal and professional growth.

- To enable the student to use the creative process to identify and solve problems in an effective way, to use structured creative thinking tools to investigate a particular matter from a variety of perspectives with clarity, to communicate and share thoughts/information accurately and effectively to understand each other, to become a team player, to value other cultures, to overcome obstacles she/he may face when performing a task, to work with hands to become better at engaging and enhancing their thought process, to get pertinent information crucial for learning about something or for communicating, to understand how decisions at the individual level or at the business level affect optimal utilisation of resources, to use conflict resolution tools to effectively resolve conflicts, to perceive emotions of themselves and of others and manage for a better outcome under various circumstances.

SYLLABUS:

- **Week 1:** Teamwork and Getting Along
- **Week 2:** Communication and Listening Skills
- **Week 3:** Cultivating a Growth Mindset
- **Week 4:** Leadership Lessons
- **Week 5:** Emotional Intelligence and Conflict Management
- **Week 6:** Systems Thinking
- **Week 7:** Engineering Sense
- **Week 8:** Fiscal and Economic Sense
- **Week 9:** Cross-cultural Understanding and Personal Grooming
- **Week 10:** Creativity and Thinking Skills
- **Week 11:** Presentation Skills
- **Week 12:** Summary

EE3107 Analog Circuits

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof. Aniruddhan S, Department of Electrical Engineering, IIT Madras

Objectives:

This course is an introduction to the analysis and understanding of transistor-based amplifiers. Students will first be introduced to basic concepts of MOS and BJT transistors, techniques for biasing them, and small-signal analysis fundamentals. This will then be extended to amplifiers, and their small- and large-signal characteristics. Frequency compensation techniques to stabilize higher order systems will be discussed. Noise in analog circuits will be introduced, analysis of noisy circuits will be studied. At the end of this course, students should be able to recognize and analyze the basic amplifiers and biasing arrangements using MOS or bipolar transistors. Students should also be able to perform dominant-pole compensation of higher order analog systems and stabilize them..

Course Contents:

- **Module 1 :** Incremental (small-signal) analysis in circuits using non-linear components; Review of MOSFET I-V characteristics
- **Module 2 :** Common source amplifier, AC coupling via capacitor, small-signal analysis of common source amplifier
- **Module 3 :** Large-signal characteristics of common source amplifier
- **Module 4 :** Negative feedback biasing of common source amplifier
- **Module 5 :** PMOS transistor; amplifiers using PMOS transistor
- **Module 6 :** Common Drain, Common Gate and Transimpedance amplifiers
- **Module 7 :** Active loads, CMOS inverter and its biasing
- **Module 8 :** Differential Amplifiers; Single-stage opamp
- **Module 9 :** MOSFET capacitances; frequency response of amplifiers; frequency compensation
- **Module 10 :** Two-stage opamp; Miller Effect; Dominant pole compensation of two-stage opamp
- **Module 11 :** Review of BJT I-V characteristics; BJT Common Emitter, Common Base and Common Collector amplifiers
- **Module 12 :** Noise in analog circuits; Thermal noise, Flicker noise; Input-referred noise

Text Books:

1. Microelectronic Circuits: Theory and Applications (International Version) Paperback – 11 Mar 2013 by A. Sedra, K. Smith, A. Chandorkar; Publisher: Oxford; Sixth edition (11 March 2013); ISBN-13: 978-0198089131

Reference Books:

1. Design of Analog CMOS Integrated Circuits (2nd edition) Paperback – 1 Nov 2017 by Behzad Razavi; Publisher: McGraw Hill Education (India); ISBN-10 : 938706784X; ISBN-13 : 978-9325983274

EE5102 Digital IC Design

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof. Janakiraman Viraraghavan,Electrical Engineering Department,IIT Madras

Objectives:

This is a most fundamental Digital Circuit Design course for pursuing a major in VLSI. We discuss transistor level circuit design concepts in great detail. Learning objectives of this course are:

• Characterize the key delay quantities of a standard cell
• Evaluate power dissipated in a circuit (dynamic and leakage)
• Design a circuit to perform a certain functionality with specified speed
• Identify the critical path of a combinational circuit
• Convert the combinational block to pipelined circuit
• Calculate the maximum (worst case) operating frequency of the designed circuit

Course Contents:

- **Module 1 :**The CMOS Inverter construction and Voltage Transfer Characteristics
- **Module 2 :** Resistance and Capacitance and transient response.
- **Module 3 :** Dynamic, Short Circuit and Leakage power – Stacking Effect
- **Module 4 :** Combinational Circuit Design and capacitance
- **Module 5 :** Parasitic Delay, Logical Effort and Electrical Effort
- **Module 6 :** Gate sizing and Buffering
- **Module 7 :** Asymmetric gate, Skewed gates, Ratioed logic
- **Module 8 :** Dynamic Gates and Domino logic and Static Timing Analysis
- **Module 9 :** Sequential circuits and feedback. Various D flip flop circuits – Static and Dynamic
- **Module 10 :** Setup and Hold Time measurement. Timing analysis of latch/ flop based systems
- **Module 11 :** Adders – Mirror adder, Carry Skip adder, Carry Select adder, Square Root adder
- **Module 12 :** Multipliers – Signed and Unsigned arithmetic, Carry Save Multiplier implementation

Text Books:

1. Digital Integrated Circuits Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic 2nd Edition, Prentice Hall India, 2003
2. CMOS VLSI Design, Neil H.E. Weste, David Harris and Ayan Banerjee, 3rd Edition, Pearson Education, 2012

Reference Books:

1. Prof. Vinita Vasudevan's lecture notes on adders and multipliers [http://www.ee.iitm.ac.in/vinita/digic.html]

EE5104 Biomedical Electronic Systems

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

Objectives:

This course provides an understanding of biopotential recording, electrical stimulation, and implantable devices, covering design principles, safety, and applications in pacemakers, defibrillators, cochlear implants, brain stimulators, and retinal implants.

Course Contents:

- **Module 1:**
  - Biopotential recording :
    - ECG, EMG, EEG, Action potentials i. Physiological origin and characteristics ii. Electrical characteristics
    - Biopotential amplifiers i. Electrode-tissue-electronics interface ii. Operation and design principles
    - Noise and interference i. Sources and pathways ii. System and circuit design for noise mitigation
- **Module 2:**
  - Electrical stimulation of cells :
    - Nerve and muscle stimulation i. Basics of electrical stimulation of excitable cells ii. Stimulation parameters
    - Safety i. Electrochemical safety ii. Tissue safety
    - Stimulation electronics i. Electrode-tissue-electronics interface ii. Operation and design principles
- **Module 3:**
  - Implantable electronic devices :
    - Wireless power and data transmission i. Inductive, RF and optical links ii. Design parameters and principles
    - Safety and compatibility i. Regulations and standards ii. Design for safety and compatibility
- **Module 4:**
  - Cardiac electronic devices :
    - Pacemakers i. Cardiac pacing mechanisms ii. Operation and design principles.
    - Defibrillators i. Fibrillation mechanisms ii. Operation and design principles
- **Module 5:**
  - Neural electronic implants :
    - Cochlear implants i. Deafness and Auditory nerve stimulation ii. Operation and design principles
    - Brain stimulators i. Deep brain and vagus nerve stimulation ii. Operation and design principles
    - Retinal implants i. Retinal blindness and Retinal stimulation ii. Operation and design principles

Text Books:

1. "Medical Instrumentation: Application and Design" by John G. Webster; 4th ed., 2009
2. "Bioelectricity: A Quantitative Approach" by Robert Plonsey and Roger C. Barr; 3rd ed., 2007

Reference Books:

1. "Implantable Medical Electronics: Prosthetics, Drug Delivery, and Health Monitoring" by Dennis Fitzpatrick., 2015

EE5103 Power Management for Electronic Systems

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

4-0-0-4

Objectives:

This course aims to provide students with a comprehensive understanding of the principles and applications of power management systems in electronics. It covers various aspects such as voltage regulation, linear and switching regulators, power management techniques for mobile systems, and battery management. Students will gain practical knowledge on how to design, select, and implement power management components, as well as optimize performance.

Course Contents:

- **Module 1:**
  - Introduction to power management:
    - What is power management, application, need of power management, different parts of a power management system, discrete vs integrated power management.
- **Module 2:**
  - Voltage Regulator:
    - What is a voltage regulator, why we need a regulator, types of voltage regulator – Linear and Switching, isolated and non-isolated regulator, choosing between types of regulators, features and performance metrics of voltage regulators, examples of voltage regulators available from different companies, how to select the right voltage regulator for an electronic system.
- **Module 3:**
  - Linear Regulators and LDOs:
    - Basic concept of linear regulator, Devices used for pass element, Performance parameters, characteristic of an error amplifier, stability analysis and compensation techniques, overcurrent and short circuit protection, Sources of error/offset in LDO, error correction techniques.
- **Module 4:**
  - Switching Regulators:
    - Basic operation, switching vs linear regulator, types of switching regulators, Losses in switching regulators, Volt-second balance, Control techniques (voltage mode, current mode, hysteretic control), voltage and current ripples, CCM and DCM operation, PSM and PFM operation, types of PWM – trailing, leading and dual edge modulation.

- **Module 5:**
    - Designing a buck converter:
        - Specifications of a buck converter, selecting switching frequency, choosing L and C, selecting power FETs, gate driver circuits, board level component placement and layout, EMI considerations

- **Module 6:**
    - Power Management for Mobile System:
        - Power management system of a mobile phone, selecting type of regulator, power distribution in a mobile phone, power sequencing, UVLO and Power ON reset, temperature and current derating, power management for mobile displays, LED driver for display backlight, controlling display brightness.
- **Module 7:**
    - Battery Chargers and Battery Management:
        - Classifications of batteries, Li-ion battery profile, battery model, different stages of battery charging, sensing battery current, compensating battery ESR, fast charging techniques, charging parallel and series batteries, state of charge estimation, voltage vs current mode battery management, battery insertion and removal detection.
- **Module 8:**
    - Power Management for IoT Application:
        - Power requirement of IoT sensors, powering sensors from energy harvesting, source of energy (solar, thermal, vibration, RF etc.), application of energy harvesting, charge storage devices (super capacitors, batteries etc.), charging system for energy harvesting, maximum power point tracking, ultra-low power voltage regulators for energy harvesting, system level power reduction techniques.

Text Books:

1. "Designing Control Loops for Linear and Switching Power Supplies: A Tutorial Guide" by Christophe Basso; 1st ed., 2012
2. "Practical Power Supply Design" by Ron Lenk; 1st ed., 2005

Reference Books:

1. "Battery Management Systems: Design by Modelling" by Gregory L. Plett., 2001

EE3106 Semiconductor Devices and VLSI Technology

- **LECTURES-TUTORIALS-PRACTICALS-CREDITS :**

  4-0-0-4

Objectives:

Develop an undergraduate level understanding of semiconductor physics, and use this to study the operation of basic two-terminal and three-terminal semiconductor devices. The students will also be introduced to the unit processes involved in microfabrication and the process integration needed for high volume IC manufacturing.

Course Contents:

- **Module 1 :**History and relevance of semiconductor devices in modern world; Solids, Crystals and Electronic grade materials; Formation of energy bands in solids; Concept of hole, Density of states

and Fermi level. Intrinsic and extrinsic semiconductors; Equilibrium Carrier concentration; Direct and indirect semiconductors; Recombination and Generation of carriers; Carrier transport – Drift and Diffusion; Equations of state – Continuity and Poisson equation

- **Module 2 :** PN junction – energy band diagram, characteristics and modeling; LEDs, Solar cells, Metal Semiconductor contacts.

- **Module 3 :** MOS capacitor; MOSFET – energy band diagram, characteristics and modeling; CMOS inverter, Scaled MOSFETs. Bipolar junction transistors – physics and characteristics;

- **Module 4 :** Overview of Semiconductor manufacturing; Silicon wafer production; Unit processes – Oxidation, Diffusion, Ion-implantation, Lithography, Deposition, Etching; Fabrication process flow of PN junction diode and MOSFET

Text Books:

1. Donald A. Neamen, “Semiconductor Physics and Devices- Basic Principles,” McGraw Hill, 2021
2. Robert Pierret, “Semiconductor Device Fundamentals,” Pearson Education, 2006
3. James D. Plummer and Peter B. Griffin, “Integrated Circuit Fabrication: Science and Technology,” Cambridge University Press, 2023
4. Hong Xiao, “Introduction to Semiconductor Manufacturing Technology,” SPIE press, 2012.

Reference Books:

1. Jesús A. del Alamo, “Integrated Microelectronic Devices: Physics and Modeling,” Pearson, 2017
2. Robert Doering & Yoshio Nishi, "Handbook of Semiconductor Manufacturing Technology," CRC press, 2007
3. Amitava DasGupta and Nandita DasGupta, “Semiconductor Devices: Modelling and Technology”, Prentice Hall India, 2004
4. S. Karmalkar, “Solid State Devices”, NPTEL video lectures
5. Nandita DasGupta, “VLSI Technology” NPTEL video lectures

MA3101 Probability and Statistics

- **LECTURES-TUTORIALS-PRACTICALS-CREDITS :**

  4-0-0-4

Objectives:
To introduce the foundations of probability and statistics in the context of electronic systems.

Course Contents:

- **Module 1:**
  - Probability space:
    - Experiments, outcomes, sample space, events, Probability function, Axioms, Addition rule
    - Computing probabilities, Conditional probability, Multiplication rule
    - Bayes’ theorem, Total probability, Independence

- **Module 2:**
  - Discrete and continuous random variables:

        - Bernoulli trials, Binomial distribution, Geometric distribution
        - Discrete random variables, PMFs, Poisson distribution
        - Multiple discrete random variables, Joint, Marginal and Conditional PMFs
        - Functions of a discrete RV, Functions of multiple discrete RVs
        - Expected value, Mean and Variance, Correlation and covariance
        - From discrete to continuous distributions, Continuous CDFs, Densities, Common distributions
        - Functions of a continuous RV, Expectations
        - Multiple continuous RVs, Joint, Marginal and Conditional densities, Independence, Histograms

- **Module 3:**
    - Limit theorems:
        - IID samples, Sample descriptive statistics, Empirical distribution, Normal sample statistics
        - Sum of independent RVs, Law of large numbers, Central limit theorem.

- **Module 4:**
    - Estimation:
        - MMSE estimators, Bayesian estimators, Maximum likelihood estimators.

Text Books:

1. Probability and Statistics, Morris DeGroot and Mark Schervish, Pearson; 4th ed., 2010
2. A Modern Introduction to Probability and Statistics, F. M. Dekking, C. Kraaikamp, H. P. Lopuhaa and L. E. Meester, Springer; 1st ed., 2005

Reference Books:

1. Probability and Random Processes, G. Grimmett and D. Stirzaker, Oxford,3rd ed., 2001

EE4108 Electronic Testing and Measurement

- **LECTURES-TUTORIALS-PRACTICALS-CREDITS :**

  4-0-0-4

Objectives:

This course is intended for students who are pursuing a BS in electronics at IIT Madras. It is assumed that the students have taken a course on Digital Design and a course on Analog Design. A course on VLSI design will be beneficial, but we will not require it. We assume that the course will be pre-recorded and there will be about 35 to 40 lectures of 1 hour duration.

Course Contents:

- **Module 1: INTRODUCTION TO ELECTRONIC TESTING**

  In this module, the students will learn about the importance of hardware testing and the career paths in the domain of testing. Homework/exercises will include objective-type questions to assess their

understanding of concepts.
1) Why Testing? – Importance of electronic testing in manufacturing and design
2) Types of Testing – Validation, characterization, debugging, production testing, reliability testing
3) Basic Testing Concepts – Fault models, defect vs. fault, test coverage
4) Measurement Fundamentals – Accuracy, precision, error sources, calibration

- **Module 2: DIGITAL CIRCUIT TESTING**
  This module will consider fault models for digital circuit testing. Homework/exercises will include paper-and-pencil exercises as well as exercises based on web-based tools.
  1) Testing Digital Circuits – Stuck-at faults, transition faults
  2) Combinational vs. Sequential Testing – Challenges in sequential circuits
  3) Scan Chains & Built-In Self-Test (BIST) – Concept, examples
  4) Fault Simulation & ATPG – Introduction to test generation
  5) Built-in Self Test
  6) Automated Digital Testing (ATE) – How large-scale testing works

- **Module 3: TEST EQUIPMENT AND MEASUREMENT TECHNIQUES**
  Electronic test engineers must be comfortable in the use of a variety of lab instruments. In this module, we will provide an overview of different measuring instruments typically used in testing. Free web-based tools will be used for demonstration and for exercises. Homework/exercises will include the use of tools.
  1) Multimeters and Oscilloscopes – Basic functions, usage, pros/cons
  2) Signal Generators & Spectrum Analyzers – Use in frequency-domain analysis
  3) Logic Analyzers & Protocol Analyzers – Debugging digital circuits
  4) Power Supplies & Load Testers – Power integrity testing
  5) Testing in Time vs. Frequency Domain – FFT analysis
  6) Noise and Interference in Measurements – Common mistakes in testing

- **Module 4: ANALOG & MIXED-SIGNAL TESTING**
  This module will consider the testing of analog circuits.
  1) Challenges in Analog Testing – Why analog is harder than digital
  2) DC and AC Testing of Analog Circuits – Gain, bandwidth, linearity
  3) Distortion and Noise Measurement – THD, SNR, dynamic range
  4) ADC/DAC Testing – Linearity, monotonicity, DNL, INL
  5) Testing RF & Communication Circuits – Key parameters
  6) Automated Analog & Mixed-Signal Testing – Basics

- **Module 5: MEMORY TESTING**
  This module will deal with testing of PROMs and RAMs.
  1) Functional fault models for memory testing
  2) Functional patterns for testing memories
  3) Built-in Self-Test architecture for memories
  4) Built-in Self-Repair

- **Module 6: SYSTEM TESTING & DEBUGGING**
  In this module, we will cover PCB testing and in-system testing and debugging of electronic hardware.
  1) Common PCB Faults – Open circuits, short circuits, cold solder joints
  2) Manual Debugging Techniques – Using a multimeter, continuity testing
  3) Automated Optical Inspection (AOI) & X-ray Inspection – Basics
  4) Boundary Scan (JTAG) Testing – Concept and simple example
  5) EMI/EMC Testing Basics – Why compliance is necessary

- **Module 7: SEMICONDUCTOR & IC TESTING**
  1) IC Manufacturing & Testing Flow – Wafer probing, package testing
  2) Parametric Testing – IDDQ, leakage current, threshold voltage
  3) Functional Testing of ICs – Typical methodologies

4) Burn-in Testing & Reliability – Why long-term reliability tests matter

- **Module 8: AUTOMATED TEST & DATA ANALYSIS**
  1) Concept of Automated Test Equipment (ATE) – Role in IC and PCB testing
  2) Concept of diagnostic testing
  3) Data-Driven Testing – Using machine learning for fault detection
  4) Test Cost vs. Test Quality – Optimizing test efficiency
  5) Data Analysis in Testing – Using Data Science for test data analysis
  6) Lab Automation & Scripting – Automating measurements using Python

OPEN ELECTIVES FROM BS IN DATA SCIENCE

CS2004 Machine Learning Foundations

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- **Prof.Harish Guruprasad Ramaswamy**,Department of Computer Sciences & Engineering,IIT Madras, **Prof.Arun Rajkumar**,Department of Computer Sciences & Engineering,IIT Madras,Prof.Prashanth LA,Department of Computer Sciences & Engineering,IIT Madras

COURSE DESCRIPTION:

- This course lays the groundwork for the upcoming ML courses by covering various fundamentals that do not necessarily fall under Machine Learning but are quite necessary for a comprehensive understanding of Machine Learning.

SYLLABUS:

Week 1: Introduction to machine learning
Week 2: Calculus
Week 3: Linear Algebra - Least Squares Regression
Week 4: Linear Algebra - Eigenvalues and eigenvectors
Week 5: Linear Algebra - Symmetric matrices
Week 6: Linear Algebra - Singular value decomposition, Principal Component Analysis in Image Processing
Week 7: Unconstrained Optimisation
Week 8: Convex sets, functions, and optimisation problems
Week 9: Constrained Optimisation and Lagrange Multipliers. Logistic regression as an optimization problem
Week 10: Examples of probabilistic models in machine learning problems
Week 11: Exponential Family of distributions
Week 12: Parameter estimation. Expectation Maximization

CS2001 Database Management Systems

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof.Partha Pratim Das,Department of Computer Science and Engineering,IIT Kharagpur

COURSE DESCRIPTION:

- A comprehensive introduction to databases and PostgreSQL, database management, database design, and relevant topics like database security, integrity, and concurrency.

SYLLABUS:

Week 1: Course Overview
Week 2: Relational Model and Basic SQL
Week 3: Intermediate and Advanced SQL
Week 4: Relational Query Languages and Database Design
Week 5: Functional Dependency and Normal Forms
Week 6: Functional Dependency and Normal Forms (cont.)
Week 7: Application Development
Week 8: Storage Management
Week 9: Indexing and Hashing
Week 10: Transactions
Week 11: Backup and Recovery
Week 12: Query Optimization and Conclusion

CS2002 Programming, Data Structures and Algorithms using Python

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof.Madhavan Mukund,Director, Chennai Mathematical Institute

COURSE DESCRIPTION:

- A good foundation course to introduce basic concepts in the design and analysis of algorithms as well as standard data structures, using Python as a base language for implementing these.

SYLLABUS:

- **Week 1:** Python Refresher
- **Week 2:** Complexity, Notations, Sorting and Searching Algorithms
- **Week 3:** Arrays, Lists, Stacks, Queues, Hashing
- **Week 4:** Graph Algorithms
- **Week 5:** Graph Algorithms (Continued)
- **Week 6:** Union-Find Data Structure, Priority Queue, Heap, Binary Search Tree
- **Week 7:** Balanced Search Tree, Greedy Algorithms
- **Week 8:** Divide and Conquer
- **Week 9:** Dynamic Programming
- **Week 10:** String or Pattern Matching Algorithms
- **Week 11:** Network Flows, Linear Programming, Class of Algorithms
- **Week 12:** Summary

CS2005 Programming Concepts using Java

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof.Madhavan Mukund,Director,Chennai Mathematical Institute

COURSE DESCRIPTION:

- This course uses Java to provide an understanding of core ideas in object oriented programming, exception handling, event driven programming, concurrent programming and functional programming.

SYLLABUS:

- **Week 1:** Basic Object Oriented Programming: Class Hierarchy
- **Week 2:** Basic Object Oriented Programming: Inheritance, Overriding
- **Week 3:** Basic Object Oriented Programming: Polymorphism
- **Week 4:** Basic Object Oriented Programming: Abstract Classes
- **Week 5:** Collections. Iterators.
- **Week 6:** Generics. Callbacks.
- **Week 7:** Cloning. I/O serializations. Packages
- **Week 8:** Cloning. I/O serializations. Packages (Continued)
- **Week 9:** Exception handling
- **Week 10:** Concurrent programming
- **Week 11:** Concurrent programming (Continued)
- **Week 12:** Concurrent programming (Continued)

CS2003 Modern Application Development I

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof.Nitin Chandrachoodan,Department of Electrical Engineering,IIT Madras,Thejesh GN, Independent Technologist, Multiple Affiliations.

COURSE DESCRIPTION:

- Building a modern application involves many different aspects: front end, recording transactions, storage, connecting to a remote server, using APIs etc. The courses Modern Application Development I and II go through all these aspects through a detailed and evolving case study, teaching the relevant programming skills as the course progresses.

SYLLABUS:

- **Week 1:** Basic terminologies of Web

- **Week 2:** Web Pages written in HTML and CSS
- **Week 3:** Presentation layer - View
- **Week 4:** Models - Introduction to databases
- **Week 5:** Controllers - Business logic
- **Week 6:** APIs and REST APIs
- **Week 7:** Backend Systems
- **Week 8:** Application Frontend
- **Week 9:** Application Security
- **Week 10:** Testing of Web Applications
- **Week 11:** HTML Evolution and Beyond HTML
- **Week 12:** Application Deployment

CS2006 Modern Application Development II

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof.Nitin Chandrachoodan,Department of Electrical Engineering,IIT Madras,Thejesh GN, Independent Technologist, Multiple Affiliations.

COURSE DESCRIPTION:

- Building a modern application involves many different aspects: front end, recording transactions, storage, connecting to a remote server, using APIs etc. The courses Modern Application Development I and II go through all these aspects through a detailed and evolving case study, teaching the relevant programming skills as the course progresses.

SYLLABUS:

Week 1: Basics of JavaScript
Week 2: Advanced JavaScript
Week 3: Introduction to Web Frontend

Week 4: Introduction to VueJS
Week 5: Vue with APIs
Week 6: Advanced Vuejs
Week 7: Advanced State Management
Week 8: Authentication and Designing APIs
Week 9: Asynchronous Jobs
Week 10: Inter-Service Messaging and Webhooks
Week 11: Performance
Week 12: Project

CS2007 Machine Learning Techniques

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof.Arun Rajkumar Department of Computer Science and Engineering,IIT Madras

COURSE DESCRIPTION:

- To introduce the main methods and models used in machine learning problems of regression, classification and clustering. To study the properties of these models and methods and learn about their suitability for different problems.

SYLLABUS:

Week 1: Introduction; Unsupervised Learning - Representation learning - PCA
Week 2: Unsupervised Learning - Representation learning - Kernel PCA
Week 3: Unsupervised Learning - Clustering - K-means/Kernel K-means
Week 4: Unsupervised Learning - Estimation - Recap of MLE + Bayesian estimation, Gaussian Mixture Model - EM algorithm.
Week 5: Supervised Learning - Regression - Least Squares; Bayesian view
Week 6: Supervised Learning - Regression - Ridge/LASSO

Week 7: Supervised Learning - Classification - K-NN, Decision tree
Week 8: Supervised Learning - Classification - Generative Models - Naive Bayes
Week 9: Discriminative Models - Perceptron; Logistic Regression
Week 10: Support Vector Machines
Week 11: Ensemble methods - Bagging and Boosting (Adaboost)
Week 12: Artificial Neural networks: Multiclass classification.

CS2008 Machine Learning Practice

LECTURES-TUTORIALS-PRACTICALS-CREDITS :

- 4-0-0-4

INSTRUCTOR(S):

- Prof.Ashish Tendulkar,Google AI,Google

COURSE DESCRIPTION:

- This companion course to the ML Theory course introduces the student to scikit-learn, a popular Python machine learning module, to provide hands-on problem solving experience for all the methods and models learnt in the Theory course.

SYLLABUS:

- **Week 1:** End-to-end machine learning project on scikit-learn
- **Week 2:** Graph Theory(VOL 3)
- **Week 3:** Regression on scikit-learn - Linear regression Gradient descent - batch and stochastic.
- **Week 4:** Polynomial regression, Regularized models
- **Week 5:** Logistic regression
- **Week 6:** Classification on scikit-learn - Binary classifier

- **Week 7:** Classification on scikit-learn - Multiclass classifier
- **Week 8:** Support Vector Machines using scikit-learn
- **Week 9:** Decision Trees, Ensemble Learning and Random Forests
- **Week 10:** Decision Trees, Ensemble Learning and Random Forests (Continued)
- **Week 11:** Neural networks models in scikit-learn
- **Week 12:** Unsupervised learning

CS3004 Deep Learning

INSTRUCTOR(S):

- Prof Mitesh Khapra,Department of Computer Science and Engineering,IIT Madras

COURSE DESCRIPTION:

- To study the basics of Neural Networks and their various variants such as the Convolutional Neural Networks and Recurrent Neural Networks, to study the different ways in which they can be used to solve problems in various domains such as Computer Vision, Speech and NLP

SYLLABUS:

- **Week 1:** History of Deep Learning, McCulloch Pitts Neuron, Thresholding Logic, Perceptron Learning Algorithm and Convergence
- **Week 2:** Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent
- **Week 3:** Feedforward Neural Networks , Representation Power of Feedforward Neural Networks, Backpropagation
- **Week 4:** Gradient Descent(GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, Adagrad, AdaDelta,RMSProp, Adam,AdaMax,NAdam, learning rate schedulers

- **Week 5:** Autoencoders and relation to PCA , Regularization in autoencoders, Denoising autoencoders, Sparse autoencoders, Contractive autoencoders
- **Week 6:** Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout
- **Week 7:** Greedy Layer Wise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization
- **Week 8:** Learning Vectorial Representations Of Words, Convolutional Neural Networks, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet
- **Week 9:** Visualizing Convolutional Neural Networks, Guided Backpropagation, Deep Dream, Deep Art, Fooling Convolutional Neural Networks
- **Week 10:** Recurrent Neural Networks, Backpropagation Through Time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT
- **Week 11:** Gated Recurrent Units (GRUs), Long Short Term Memory (LSTM) Cells, Solving the vanishing gradient problem with LSTM
- **Week 12:** Encoder Decoder Models, Attention Mechanism, Attention over images, Hierarchical Attention, Transformers.

EE4001 Speech Technology

INSTRUCTOR(S):

- Prof. Umesh,Department of Electrical Engineering,IIT Madras , Prof. Hema A Murthy,Department of Computer Science and Engineering,IIT Madras

COURSE DESCRIPTION:

- To understand the concepts of speech and speech technologies, and to apply them to real-world scenarios
- To gain hands-on experience of the relevant toolkits used for speech processing

SYLLABUS:

- **Week 1:** Review of Signals and Systems, Continuous time signals and transforms
  Discrete time signals, Discrete Fourier transform, Autocorrelation and Cross-Correlation
- **Week 2:** Acoustic Feature Analysis of Speech Signals I, II
- Gaussian mixture models (GMM), universal background model (UBM-GMM), singular value decomposition (SVD)
- **Week 3:** Hidden Markov model (HMM), Examples of HMM based approach for ASR, TTS, speaker diarization
  Information bottleneck (IB) based clustering for diarization
- **Week 4:** Introduction and History of ASR and TTS

- Components of ASR: Acoustic Modelling, Punctuation Model (Lexicon) and language modelling (N-Gram Language models)
- **Week 5:** HMMs for Acoustic Modelling - Monophone, Triphone
  Speech Synthesis: unit selection, statistical parametric synthesis (HTS)
- **Week 6:** Neural networks for building speech technologies
  NN for Acoustic Modelling - Hybrid modelling- Hybrid-NN: DNN,CNN,TDNN
- **Week 7:** End-to-End Approaches I:
  CTC, Encoder-decoder Architecture E2E with RNN;
- **Week 8:** Applications to ASR and TTS
  End-to-End Approaches II:
- **Week 9:** Encoder-decoder Architecture E2E with transformers for ASR and TTS
  Interesting Problems:
- **Week 10:** Speaker recognition/verification: with ivector, xvector
  Speaker diarization: using x-vector
- **Week 11:** Speaker adaptation: (revisit i, x vectors) and introduce s-vectors.
  Code Switched Speech recognition; Speech Translation;
- **Week 12:** Singing voice synthesis; voice conversion; generic voice synthesis

DA5013 Deep Learning Practice

INSTRUCTOR(S):

Prof. Mitesh M.Khapra , Prof. S. Umesh , Dr. Kaushik Mitra

- Week 1:
  - Introduction to Modern NLP and HF
    - Introduction to Modern NLP with transformers.
    - Introduction to Hugging Face Ecosystem: Datasets, Tokenizer, Transformers, Trainers, Accelerate (slides)
    - Dive into the datasets module (code)
    - Loading datasets from the hub, local files, understanding the base class
    - Some frequently used methods: map, filter, select, flatten, concatenate, interleave
    - Load large datasets by streaming
    - (optional) Building datasets by scraping web (slides/code)

- Week2
  - Tokenization
    - Understand the working principle of different tokenization algorithms (slides)
    - Tokenizer pipeline
      - Normalization
      - Pre-tokenization
      - Tokenization algorithm
      - Post-processing

        - Training a tokenizer to learn the vocabulary (code)
        - Encoding and decoding of samples (code)

- Week3
    - Fine-tuning models for downstream tasks
        - Use pre-trained models for various NLP tasks
        - Fine-tune models on the task-specific datasets
            - Freeze the pre-trained model parameters and only fine-tune the task-specific head
            - Full parameter fine-tuning
        - Performance evaluation using appropriate metrics

- Week4
    - Continual Pre-training and Instruction Tuning
        - Train a model from scratch using CLM and MLM objectives.
        - Memory efficient training
            - Optimizers: AdaFactor, 8-bit Adam, (Optional) GaLore
            - Gradient Accumulation
            - Activation Checkpointing
            - Mixed Precision Training
        - Continual pre-training using PEFT (LORA, QLORA)
        - (optional) Instruction tuning

- Week5
    - Spoken Language Identification
- Week6
    - Speaker Diarisation (identifying speakers and when they are spoken in a conversation)
- Week7
    - Speech to Text and Text to Speech synthesis
- Week8
    - Wake word detection like "Hey Google" or "Alexa" with personalization
- Week9
    - Image Classification
        - Models:
            - Alexnet, VggNet, ResNet
            - Explore: densenet, ViT
        - Dataset:
            - 10 class animal dataset
            - Challenges: large within variation, so difficult to classify
            - Can introduce class imbalance
- Week10
    - Object detection
        - Models: YOLO, RCNN
        - Dataset:
            - Mosquito detection and recognition
            - Challenge: No pretrained model, class imbalance
- Week11
    - Image based depth estimation
        - Dataset:
        - Challenges: low-light, so directly cannot use pre-trained models
        - Models: UNet, UNet++, Pix2Pix

- Week12
    - Image super-resolution
        - Dataset: Medical image dataset
        - Challenges: no pretrained model
        - Models:
            - SRGan

MS3001 Design Thinking for Data-Driven App Development

INSTRUCTOR(S):

- Prof. Bala Ramadurai,Consultant and Guest Faculty, IIT Madras
- Prof. Prathap Haridoss,Department of Metallurgical and Materials Engineering, IIT Madras

COURSE DESCRIPTION:

- To enable the students to apply agile method to developing software, to design an app using the principles of design thinking, to develop an app for android, to collaborate with other developers using git version control method, and to learn the basics of marketing and customer support through their website

SYLLABUS:

- **Week 1:** Introduction to Design Thinking – Course Outline and Projects, Intro to Design from Everyday Life, Intro to Design Thinking in Software Apps, Project Management
- **Week 2:** Empathize – P1 – Persona Creation, Customer Journey Mapping, Demo on a real problem
- **Week 3:** Empathize – P1 – List of problems, How Might We questions, Demo on a real problem
- **Week 4:** Analyze – P1 – Multi-Why, Conflict of Interest, Demo on a real problem

- **Week 5:** Solve – P1 – Silent brainstorming, Inventive Principles, Concept creation, Demo on a real problem
- **Week 6:** Test – P1, Empathize – P2 Assumptions, Features, Field trials
- **Week 7:** Website Development, Basics of Digital Marketing, User Experience Design
- **Week 8:** Analyze – P2
- **Week 9:** Solve – P2
- **Week 10:** Test – P2, Empathize – P3 – Obtaining insights/ feedback from the customers or target users
- **Week 11:** Analyze – P3
- **Week 12:** Test – P3, Launch of the App

MS4001 Industry 4.0

INSTRUCTOR(S):

- Dr. Rahul Marathe,Department of Management Studies, IIT Madras, Dr. Amit,Department of Management Studies, IIT Madras

COURSE DESCRIPTION:

- To describe various facets of Industry 4.0, to connect questions raised by Industry 4.0 with appropriate data science techniques, to develop data science tools for Industry 4.0, and to build data-centric business models.

SYLLABUS:

- **Week 1:** Introduction to Industry 4.0 – Evolution and history
- **Week 2:** Pillars of Industry 4.0
- **Week 3:** Industry 4.0 – India context
- **Week 4:** Supplier selection as a classification problem
- **Week 5:** Manufacturing 4.0
- **Week 6:** Prognosis
- **Week 7:** Quality 4.0

- **Week 8:** Inventory Optimization
- **Week 9:** Dynamic Pricing
- **Week 10:** Logistics 4.0
- **Week 11:** Future of Manufacturing Business Focus on new paradigm
- **Week 12:** Next decade of Industry 4.0

GN3002 Financial Forensics

INSTRUCTOR(S):

- **Dr. Arun Kumar G,Department of Management Studied (DOMS), IIT MADRAS**

COURSE DESCRIPTION:

SYLLABUS:

- **Week 1:** INTRODUCTION TO ACCOUNTING AND FINANCE:Financial Statements,Uses relevance of financial statements,Decision making in the financial arena,Need for finance and accounting in a business world
- **Week 2:** FRAUD VULNERABILITIES AND FINANCE:Types of fraud,Why do they occur,Where do they occur,Detecting red flags
- **Week 3:** FORENSIC ACCOUNTING - 1:Intro to Forensic Accounting ,Source of assignments and referrals for a forensic accountant,Role of the forensic accountant as an expert - identify any conflicts
- **Week 4:** FORENSIC ACCOUNTING - 2:Scope of forensic accounting,Process of forensic accounting - Analysis
- **Week 5:** BENFORD LAW AND IMPLEMENTATION:Benford Law,Using Benford Law in Excel to detect audit fraud

- **Week 6:** AGING ANALYSIS, PARETO AND OUTLIERS:Detecting fraud using Aging Analysis in Excel,Creating a Pareto Chart,Outlier identification
- **Week 7:** FINANCIAL TRANSACTION LIFECYCLE:Transaction Lifecycle,Where is AI/ML used in the present world?
- **Week 8:** ENTITY RESOLUTION:What is an entity in a transaction?,Entity resolution
- **Week 9:** ANOMALY DETECTION - 1:Supervised Anomaly Detection
- **Week 10:** "ANOMALY DETECTION - 2:Unsupervised Anomaly Detection
- **Week 11:**Model Explainability:Financial Data Visualization using Tableau

MS3002 Market Research

INSTRUCTOR(S):

- Prof. Ashok Sankethi, Kaybase Research

COURSE DESCRIPTION:

- To provide a basic understanding of research methodology and its implementation in different business domains, to understand the role, scope, process, cost, and value of marketing research, to match research techniques to marketing problems, to analyse data and translate them into actionable findings, to enable students to do hands-on research to solve business problems.

SYLLABUS:

- **Week 1:** The Role of Research in Marketing and the Marketing Research Process, Defining the Marketing Research Problem and Developing an Approach
- **Week 2:** Research Design, Exploratory Research Design, Descriptive Research Design, Causal Research Design and Test Markets

- **Week 3:** Surveys and Interviews, Measurement, Measurement Scales, Questionnaires, and Instruments
- **Week 4:** Key marketing issues like new product development, STP, branding, etc. and the MR tools and techniques to address each
- **Week 5:** Entering the Data in SPSS, Examining the Data and Univariate Data Analysis: Descriptive Statistics, Cross Tabulation, Graphical Display of Data, Chart Deception and Hypothesis Testing: Mean Differences, ANOVA, Multivariate Data Analysis: An Overview, Exploratory Factor Analysis, Cluster Analysis, Multiple Regression in SPSS

MS4023 Game Theory and Strategy

INSTRUCTOR(S): Dr. Bikramaditya Datta & Vimal Kumar

- Week 1: Introduction and General Principles
- Week2: Games with Simultaneous Moves I
- Week3: Games with Simultaneous Move II
- Week4: Games with Sequential Moves
- Week5: Combining Sequential and Simultaneous Moves and Mixed Strategies
- Week6: Evolutionary game Theory
- Week7: Matching Problem, Gale-Shapley Algorithm
- Week8: Voting, Cascades, and Arrow's Impossibility Theorem
- Week9: Cooperative Games, Shapley Values
- Week10: Fair Division, Bankruptcy Problems
- Week11: Auctions
- Week12: Network Effects

MS3033 Managerial Economics

INSTRUCTOR(S): Vimal Kumar

SYLLABUS:

- Week 1: Introduction
- Week2: Demand, Supply, and markets
- Week3: Elasticity and Empirical Methods for Demand Analysis
- Week4: Consumer Behavior
- Week5: Technology, Production, and Costs
- Week6: Perfectly Competitive Market
- Week7: Monopoly
- Week8: Monopsony and Monopolistic Competition
- Week9: Decisions under Risk and Uncertainty
- Week10: Asymmetric Information
- Week11: Government and Businesses
- Week12: Platform Businesses

MS3034 Corporate Finance

INSTRUCTOR(S): Dr. Bikramaditya Datta

- Week 1: Introduction to Finance
- Week2: Present Value, Annuities and Perpetuities
- Week3: Capital Budgeting Rules, Time Varying Rates of Return, Uncertainty, Default and Risk
- Week4: Investment: Risk and Rewards, Choice Under Uncertainty
- Week5: Portfolio Theory
- Week6: Capital Asset Pricing Theory
- Week7: Other Pricing Models: Factor Models, Arbitrage Pricing Theory
- Week8: Market Efficiency: Market Imperfections, and Applications to Capital Budgeting Rules
- Week9: Introduction to Derivative Securities and Basic Options Theory I
- Week10: Introduction to Derivative Securities and Basic Options Theory II
- Week11: Foreign Exchange Markets and International Financial System
- Week12: Financial Crises