B. Tech. (ECE) – 2020 Curriculum

Course Code	Semester - I	Credit
MA101	Mathematics - I	3
CS101	Introduction to Computer Programming	3
EC151	Basics of Electrical and Electronics Engineering	3
ME151	Engineering Graphics	3
ME101	Basics of Mechanical Engineering	2
EC101	Electrical Laboratory	2
CS102	Introduction to Computer Programming Laboratory	2
ME102	Engineering Practice	2
HM102	NSS/NSO/NCC	0
	Total Credits	20

Course Code	Semester – II	Credit
HM101	English for Communication (Theory and Lab)	2
MA151	Mathematics – II	3
PH101	Physics	3
CS151	Introduction to Python Programming	3(2T+2L)
EC152	Programme Core -I / Digital Principles and System Design	3
EC153	Programme Core -II / Solid-State Devices	3
ME152	Energy and Environmental Engineering	0
PH102	Physics Laboratory	2
EC154	Digital Principles & System Design Laboratory	2
	Total Credits	21

Course Code	Semester – III	Credit
MA201	Mathematics -III	3
EC201	Programme Core -III / Electronic Circuits	3
EC202	Programme Core -IV / Network Analysis & Synthesis	3
EC203	Programme Core -V / Signals and Systems	3
HM251	Economics for Engineers	3
EC204	Data Structures and Algorithms	3
EC205	Electronic Circuits Laboratory	2
EC206	Electrical Networks Laboratory	2
	Total Credits	22

Course Code	Semester – IV	Credit
MA252	Programme Core -VI /Probability and Random Processes	4
EC251	Programme Core -VII / Embedded Systems	3
EC252	Programme Core -VIII /Analog Integrated Circuits	3
EC253	Programme Core – IX / Communication Theory	3
EC254	Programme Core – X / Control Systems	3
EC255	Computer Networks	3
EC256	Embedded Systems Laboratory	2
EC257	Analog Integrated Circuits Laboratory	2
HM301	Professional Ethics	0
	Total Credits	23

Course Code	Semester – V	Credit
EC301	Programme Core – XI / Engineering Electromagnetics	3
EC302	Programme Core – XII / Antenna and Wave Propagation	3
EC303	Programme Core – XIII /VLSI System Design	3
EC304	Programme Core – XIV /Digital Communication	3
E1	Elective -I	3
GE1	Global Elective -I	3
EC305	Digital Communication Laboratory	2
EC306	VLSI Design Laboratory	2
	Total Credits	22

Course Code	Semester – VI	Credit
EC351	Programme Core – XV /Digital Signal Processing	3
EC352	Programme Core – XVI / Optical Communication	3
EC353	Programme Core – XVII / RF and Microwave Engineering	3
HM351	Technical English	2
E2	Elective -II	3
GE2	Global Elective -II (Economics)	3
EC354	Digital Signal Processing Laboratory	2
EC355	Microwave and Optical Communication Laboratory	2
	Total Credits	21

Course Code	Semester – VII	Credit
EC401	Summer Internship	2
EC402	Programme Core - XVIII /Wireless and Cellular Communication	3
E3	Elective -III	3
E4	Elective -IV	3
E5	Elective -V	3
E6	Elective -VI	3
EC403	Wireless and Cellular Communication Laboratory	2
	Total Credits	19

Course Code	Semester – VIII	Credit
EC451	Comprehensive Viva	1
EC452	Project work	6
E7	Elective - VII / MOOC online course	3
E8	Elective -VIII / MOOC online course	3
E9	Elective -IX / MOOC online course	3
	Total Credits	16

Summary:

Branch/Sem	I	II	III	IV	V	VI	VII	VIII	Total
ECE	20	21	22	23	22	21	19	16	164

Electives

Elective / Specialization	Devices & Circuits	VLSI	Communication	CSE based	Others
Elective-I	Analog IC Design	Introduction to VHDL/Verilog programming	Communication Switching Systems	Advanced Computer Architecture	Principles of Management
Elective-II	Analog CMOS Design	DSP structure for VLSI	Mobile Communication	High Speed Networks	MEMS
Elective-III	Mixed - Signal Circuit Design	Design of ASICs	Information Theory and Coding	Robotics	Automotive Electronics
Elective-IV	High Speed Communication Circuits and Systems	VLSI System Testing	Software Radio	Deep Learning and Neural networks	Measurement and Instrumentation
Elective-V	FPGA Based system design	Process and Fabrication Technology	Telecommunication System Modelling and Simulation	Ad hoc Wireless Networks	
Elective-VI	Asynchronous System Design	Digital Signal Processors and Applications	Satellite Communication	Secure Communication	
Elective-VII	Formal Methods for System Verification	CMOS VLSI Design	Cognitive Radio	Essential Coding Theory	
Elective-VIII	Physical Design Automation	VLSI Digital Signal Processing Systems	Broadband Access Technologies	Pattern Recognition	
Elective-IX	Nanoelectronics	Digital Image Processing	Radar Engineering	Virtual reality	

Global Electives

Global Elective -I	Global Elective -II
Internet of Things	Intellectual Property Rights
Web Programming	Economics for IT
Machine Learning	Health Economics and Health Technology Assessment
	Managerial Economics
	Management Information Systems

Course Code	Electives	Credit
Elective I		
EC511	Analog IC Design	3
EC512	Introduction to VHDL/Verilog programming	3
EC513	Communication Switching Systems	3
CS511	Advanced Computer Architecture	3
EC514	Principles of Management	3
Elective II		
EC515	Analog CMOS Design	3
EC516	DSP structure for VLSI	3
EC517	Mobile Communication	3
EC518	High Speed Networks	3
EC519	MEMS	3
Elective III		
EC520	Mixed - Signal Circuit Design	3
EC521	Design of ASICs	3
CS649	Information Theory and Coding	3
CS650	Robotics	3
EC522	Automotive Electronics	3
Elective IV		
EC523	High Speed Communication Circuits and Systems	3
EC524	VLSI System Testing	3
EC525	Software Radio	3
EC526	Deep Learning and Neural networks	3
EC527	Measurement and Instrumentation	3
Elective V		
EC528	FPGA Based system design	3
EC529	Process and Fabrication Technology	3
EC530	Telecommunication System Modelling and	3

	Simulation	
EC531	Ad hoc Wireless Networks	3
Elective VI		
EC532	Asynchronous System Design	3
EC533	Digital Signal Processors and Applications	3
EC534	Satellite Communication	3
EC535	Secure Communication	3
Elective VII		
EC536	Formal Methods for System Verification	3
EC537	CMOS VLSI Design	3
EC538	Cognitive Radio	3
EC539	Essential Coding Theory	3
Elective VIII		
EC540	Physical Design Automation	3
EC541	VLSI Digital Signal Processing Systems	3
EC542	Broadband Access Technologies	3
CS542	Pattern Recognition	3
Elective IX		
EC543	Nanoelectronics	3
CS647	Digital Image Processing	3
EC544	Radar Engineering	3
CS541	Virtual reality	3

Global Elective – I		
CS646	Internet of Things	3
EC645	Machine Learning	3
EC646	Web Programming	3
Global Elective – II		
HM611	Intellectual Property Rights	3
HM612	Economics for IT	3
HM613	Health Economics and Health Technology Assessment	3
HM614	Managerial Economics	3
HM615	Management Information Systems	3

FIRST SEMESTER

Course Code	:	MA101
Course Title	:	**Mathematics – I**
Number of Credits	:	3
Prerequisites (Course Code)	:	None
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1 Examine the system of linear equations with matrices.

CO2 Convert linear first order differential equations into separable form.

CO3 Solve the ordinary linear differential equations with constant coefficients

CO4 Identify the maxima and minima of multivariable functions

CO5 Analyze the physical problems that arise in the field of engineering and apply the concepts to solve them.

Course Content:

Matrices: Rank of a matrix - Consistency of the system of linear equations - linear dependence and independence of vectors. Eigen values and Eigen vectors of a matrix - Caley-Hamilton theorem and its applications - Reduction to diagonal form - Reduction of a quadratic form to canonical form - orthogonal transformation and congruent transformation. Properties of complex matrices - Hermitian, skew-Hermitian and Unitary matrices.

Ordinary differential equations of first order: Separable equations - equations reducible to separable form - exact equations - integrating factors. Linear first order equations - Bernoulli's equation - Orthogonal trajectories - Newton's law of cooling - Law of natural growth and decay.

Ordinary higher order differential equations: Higher order linear equations with constant coefficients. Euler and Cauchy's equations - Method of variation of parameters - System of linear differential equations with constant coefficients – Applications to electrical circuits.

Differential Calculus: Rolle's theorem - Mean value theorem - Taylor's and Maclaurin's theorems (without proof) with remainders – simple illustrations; Functions of several variables - Partial differentiation - Total Differentiation - Euler's theorem and generalization. Maxima and minima of functions of several variables (two and three variables) – Lagrange's method of Multipliers - Change of variables –Jacobians – simple illustrations.

Multiple Integrals: Double and triple integrals - computation of surface areas and volumes; change of variables in double and triple integrals.

Text Books:

1 R. K. Jain and S. R. K. Iyengar, “Advanced Engineering Mathematics”, 5th ed, Narosa Publishing House, 2016.

2 B.S. Grewal, “Higher Engineering Mathematics”, Khanna Publications, 44nd ed, 2015.

3 Erwin Kreyszig, “Advanced Engineering Mathematics”, 8th ed, John Wiley and Sons, 2015.

Reference Books:

1 N. Piskunov, “Differential and Integral calculus”, Vol. 1&2, MIR Publishers, Moscow - CBS Publishers and Distributors (India).

2 Michael D. Greenberg,“Advanced Engineering Mathematics”, Pearson Education Pvt. Ltd.

Web link(s):

1 https://nptel.ac.in/courses/111/101/111101115/https://nptel.ac.in/courses/111/102/111102133/

2 https://nptel.ac.in/courses/111/104/111104092/

Course Code	:	CS101
Course Title	:	**Introduction to Computer Programming**
Number of Credits	:	3
Prerequisites (Course Code)	:	None
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the basics of computers and software systems.

CO2 Discuss the various conditional control statements in C programming.

CO3 Apply the concept of arrays to solve sorting and searching problems.

CO4 Define pointers and its association with arrays and functions in C.

CO5 Develop C program with structures and perform Read-Write operations with files.

Course Content:

Introduction to Computers, Number Systems, C language: Introduction to Computers: Computer Systems, Computing Environments, Computer Languages, Creating and Running Programs, Software Development, Flow charts. Number Systems: Binary, Octal, Decimal, Hexadecimal Introduction to C Language - Background, C Programs, Identifiers, Data Types, Variables, Constants, Input / Output Statements Arithmetic Operators and Expressions: Evaluating Expressions, Precedence and Associativity of Operators, Type Conversions.

Control Statements: Conditional Control Statements: Bitwise Operators, Relational and Logical Operators, If, If-Else, Switch-Statement and Examples. Loop Control Statements: For, While, DoWhile and Examples. Continue, Break and Goto statements Functions: Function Basics, User-defined Functions, Inter Function Communication, Standard Functions, Methods of Parameter Passing. Recursion- Recursive Functions. Storage Classes: Auto, Register, Static, Extern, Scope Rules, and Type Qualifiers

Preprocessors, Arrays: Preprocessors: Preprocessor Commands Arrays - Concepts, Using Arrays in C, Inter-Function Communication, Array Applications, Two- Dimensional Arrays, Multidimensional Arrays, Linear and Binary Search, Selection and Bubble Sort.

Pointers, Strings: Pointers - Introduction, Pointers for Inter-Function Communication, Pointers to Pointers, Compatibility, Lvalue and Rvalue, Arrays and Pointers, Pointer Arithmetic and Arrays, Passing an Array to a Function, Memory Allocation Functions, Array of Pointers, Programming Applications, Pointers to void, Pointers to Functions, Commandline Arguments. Strings - Concepts, C Strings, String Input/Output Functions, Arrays of Strings, String Manipulation Functions.

Structures, Input and Output: Structures: Definition and Initialization of Structures, Accessing Structures, Nested Structures, Arrays of Structures, Structures and Functions, Pointers to Structures, Self Referential Structures, Unions, Type Definition (typedef), Enumerated Types. Input and Output: Introduction to Files, Modes of Files, Streams, Standard Library Input/Output Functions, Character Input/Output Functions.

Text Books:

1 R G Dromey, "How to Solve It by Computer", Prentice-Hall International Series in Computer Science, 2006.

2 G. Michael Schneider, "Invitation to Computer Science", Eighth Edition, 2018

3 Byron S Gotrified, "Programming with C", Thrid Edition, McGraw Hill Companies, 2017.

Reference Books:

1 Michael Vine, "C Programming for the Absolute Beginner", Third Edition, 2014.

2 Brian W Kernighan, Dennis M. Ritchie, "C Programming Language", Second Edition, Pearson Education India, 2015

3 Herbert Schildt, "C++ Complete Reference", McGraw Hill, Fourth Edition, 2017.

Web link(s):

1 http://uru.ac.in/uruonlinelibrary/Cloud_Computing/Basics%20of%20Computer.pdf

2 https://www.tutorialspoint.com/basics_of_computers/index.htm

3 https://en.wikiBookss.org/wiki/Computers_for_Beginners/The_Basics

4 http://ecoursesonline.iasri.res.in/course/view.php?id=

5 https://www.tutorialspoint.com/cprogramming/index.htm

Course Code	:	EC151
Course Title	:	**Basics of Electrical and Electronics Engineering**
Number of Credits	:	3
Prerequisites (Course Code)	:	None
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain basic electric terminologies, laws and parameters.

CO2 Describe the characteristics and operations of DC machines.

CO3 Illustrate the basic properties of semiconductor devices

CO4 Identify different electronic circuits with semiconductor devices and electrical elements

CO5 Explain the function of various digital logic gates and blocks.

Course Content:

Ohms Law -Kirchhoff's Laws - steady state solution of DC Circuits - Introduction to AC circuits - Waveforms and RMS value - power and power factor, single phase and three phase balanced circuits.

Principles of operation and characteristics of DC machines, Transformers - Synchronous Machines - three Phase and single phase induction motors - Moving coil and moving iron instruments (Ammeter and voltmeter).

Classification of solids based on energy hand theory - Intrinsic semiconductors - Extrinsic semiconductors - P type and N type - P-N junction – I-V characteristics of PN junction diode - Zener diode - Zener diode characteristics - Half wave and full wave rectifiers - Voltage regulation, SCR, Diac, Triac, Characteristics and simple applications.

Bipolar junction transistor - CB, CE, CC - Configurations and characteristics - Biasing circuits - Field Effect Transistor - Configurations and characteristics - FET amplifier - UJT - characteristics and simple applications - switching transistors - concept of feedback - negative feedback - application in temperature and motor speed control.

Binary number system - AND, OR, NOT, NAND, NOR circuits - Boolean algebra - Exclusive OR gate - Half and Full adders - flip flops - registers and counters - A/D, D/A conversion - Digital computer principle.

Text Books:

1 Salivahanan S, “Basic Electrical and Electronics Engineering”, Tata McGraw Hill Education (India) Private Limited, New Delhi, 2013

2 V. K. Mehta, R. Mehta, “Principles of Electrical Engineering”, S. Chand & Company Ltd., New Delhi, 2008.

3 Thomas Floyd, “Digital Fundamentals”, Prentice Hall, 10th Edition, 2011.

Reference Books:

1 Robert L. Boylestad and Louis Nashelsky, "Electronic Devices & Circuit Theory", 11/e Pearson, 2013.

Web link(s):

1 https://nptel.ac.in/courses/108/101/108101091/ (NPTEL Video by Dr.Mahesh B. Patil from IIT Bombay)

2 https://nptel.ac.in/courses/117/106/117106108/ (NPTEL Video by Prof. Nagendra Krishnapura from IIT Madras)

Course Code	:	ME151
Course Title	:	**Engineering Graphics**
Number of Credits	:	3
Prerequisites (Course Code)	:	None
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1 Discuss the fundamentals and standards of Engineering drawings/ graphics

CO2 Visualize the structure of engineering components

CO3 Create geometric construction, multi-view, dimensioning and detail drawings of typical 3-D engineering objects

CO4 Develop projections, solid objects and surfaces of engineering components

CO5 Devise 3D Isometric View in relation with 2D orthographic views

Course Content:

Fundamentals Drawing standard - BIS, dimensioning, lettering, type of lines, scaling, conventions

Geometrical constructions Dividing a given straight line into any number of equal parts, bisecting a given angle, drawing a regular polygon given one side, special methods of constructing a pentagon and hexagon – conic sections – ellipse – parabola – hyperbola – cycloid

Orthographic projection: Introduction to orthographic projection, drawing orthographic views of objects from their isometric views - Orthographic projections of points lying in four quadrants, Orthographic projection of lines parallel and inclined to one or both planes Orthographic projection of planes inclined to one or both planes. Projections of simple solids – axis perpendicular to HP, axis perpendicular to VP and axis inclined to one or both planes.

Sectioning of solids: Section planes perpendicular to one plane and parallel or inclined to other plane. Intersection of surfaces: Intersection of cylinder & cylinder, intersection of cylinder and cone, and intersection of prisms

Development of surfaces: Development of prisms, pyramids, cylindrical and conical surfaces. Isometric and perspective projection: Isometric projection and isometric views of different planes and simple solids, introduction to perspective projection

Text Books:

1 Natrajan K.V., “A text Books of Engineering Graphics”, Dhanalakshmi Publishers, Chennai,

2009.

2 Venugopal K. and Prabhu Raja V., “Engineering Graphics” New Age International (P) Limited, 2008.

3 Giesecke, F. E., Mitchell, A., Spencer, H., Hill, I., Dygdon, J., and Novak, J., “Technical drawing with engineering graphics”, 2016

Reference Books:

1 Bhatt N.D. and Panchal V.M., “Engineering Drawing”, Charotar Publishing House, 50th Edition, 2010.

2 Basant Agarwal and Agarwal C.M., “Engineering Drawing”, Tata McGraw Hill Publishing Company Limited, New Delhi, 2008.

3 Shah M.B., and Rana B.C., “Engineering Drawing”, Pearson, 2nd Edition, 2009.

Web link(s):

1 https://nptel.ac.in/courses/112/103/112103019/

2 http://www.iitg.ac.in/rkbc/me111.htm

Course Code	:	ME101
Course Title	:	**Basics of Mechanical Engineering**
Number of Credits	:	2
Prerequisites (Course Code)	:	None
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1 Discuss the basic concepts of thermodynamics, systems, and energy resources

CO2 Explain the basic functions of internal combustion engines, refrigeration, and heat transfer in engineering applications

CO3 Select a type of power transmission system as per the application

CO4 Identify the suitable Materials for Engineering Applications

CO5 Describe the functions and operations of various conventional and advanced manufacturing processes

Course Content:

Thermodynamics: Thermodynamics: Energy Sources - Conventional/Renewable, Thermodynamics - System, State, Properties, Thermodynamic Equilibrium, Process and Cycle, Fundamental Units and conversions, Zeroth law of Thermodynamics, Work and Heat, First law- Cyclic process, Change of State, Limitations of First law, Thermal Reservoirs, Heat Engine, Heat Pump/Refrigerator, Efficiency/COP, Second law, PMM2, Carnot Cycle, Entropy - Example problems.

I.C. Engines: 2-Stroke & 4-Stroke Engines, P-v Diagram; S.I. Engine, C.I. Engine, Differences, Refrigeration: Vapour Compression Refrigeration Cycle - Refrigerants, Desirable Properties of Refrigerants Heat Transfer: Modes of Heat Transfer, Thermal Resistance Concept, Composite Walls and Cylinders, and Overall Heat Transfer Coefficient - Example problems

Power Transmission: Classification of different power transmission systems, Transmission of Power, Belt Drives, Chain Drives, Gears and Gear Trains - Example problems.

Engineering Materials Properties of materials, Classification of Materials, Selection of Engineering Materials, introduction to materials structure, applications, Testing of materials.

Manufacturing Processes: Castings - Patterns and Moulding, Hot Working and Cold Working, Metal Forming processes: Extrusion, Drawing, Rolling, Forging, Welding - Arc Welding & Gas Welding, Soldering, Brazing. Advanced manufacturing: introduction to CNC machines,

laser based manufacturing processes, 3D printing.

Text Books:

1 Basant Agarwal and C.M. Agarwal, “Basic Mechanical Engineering”, Wiley India Pvt. Ltd., 2008.

2 Sadhu Singh, “Basic Mechanical Engineering”, S. Chand & Company Limited, 2009.

3 Praveen Kumar, “Basic Mechanical Engineering”, Pearson Education, India, 2013

Reference Books:

1 M.L. Mathur, F.S. Mehta and R.P. Tiwari, R.S. Vaishwnar, “Elements of Mechanical Engineering”, Jain Brothers, New Delhi, 2008.

2 P.N. Gupta, M.P. Poonia, “Elements of Mechanical Engineering”, Standard Publishers, 2004

3 C.P. Gupta, Rajendra Prakash, “Engineering Heat Transfer”, NemChand Brothers, New Delhi, 1994.

Web link(s):

1 https://nptel.ac.in/courses/112/105/112105123/

2 https://nptel.ac.in/courses/112/103/112103262/

3 https://nptel.ac.in/courses/112/105/112105234/

Course Code	:	EC101
Course Title	:	**Electrical Laboratory**
Number of Credits	:	2
Prerequisites(Course Code)	:	Basic Electrical and Electronics Engineering
Course Type	:	ELR

Course outcomes: At the end of the course, the student will be able to:

CO1 List the required instruments needed for DC and AC measurements.

CO2 Establish the desired connections among various electrical elements on a bread board.

CO3 Measure the current and voltages across various branches and nodes of the circuit connected on the bread board.

CO4 Observe and explain the working of various electrical motors.

CO5 Illustrate the difference between measurement of analog circuits and digital circuits/logic.

List of Experiments:

1. Hands on experience of measuring instruments
2. Verification of Ohm's and Kirchhoff's laws
3. Measurement of AC parameters: Magnitude and frequency
4. Study on three-phase circuit connections
5. Demonstration of working of various Electric Motors
6. Validation of characteristics of semiconductor devices
7. Design of Half-wave and full-wave rectifiers
8. Validation of Boolean expressions

Course Code	:	CS102
Course Title	:	**Introduction to Computer Programming Laboratory**
Number of Credits	:	2
Prerequisites (Course Code)	:	None
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1 Develop C program for solving basic mathematical problems.

CO2 Write C program for solving problems that require more iteration.

CO3 Construct C program for various sorting and searching algorithms.

CO4 Perform operations related to strings using C functions.

CO5 Compose file handling programs in C language.

Course Content:

1. Finding the maximum and minimum of given set of numbers
2. Finding Roots of a Quadratic Equation
3. Sin x and Cos x values using series expansion
4. Conversion of Binary to Decimal, Octal, Hexa and Vice versa
5. Generating a Pascal triangle and Pyramid of numbers
6. Recursion: Factorial, Fibonacci, GCD
7. Matrix addition and multiplication using arrays
8. Bubble Sort, Selection Sort
9. Programs on Linear Search and Binary Search using recursive and non-recursive procedures. Functions for string manipulations
10. Finding the No. of characters, words and lines of given text file
11. File Handling programs

Course Code	:	ME102
Course Title	:	**Engineering Practice**
Number of Credits	:	2
Prerequisites (Course code)	:	None
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the basic manufacturing processes of Casting, Joining, Fitting and Forming.

CO2 Use hand tools and basic machineries in Foundry, Welding shop, Carpentry, Fitting shop and Sheet Metal work

CO3 Design simple prototypes and produce engineering products.

Course Content:

Foundry: Preparation of sand mould for the following
01. Flange
02. Hand Wheel
Welding: Fabrication of metals joint of the following
01. Butt Joint
02. Lap Joint
Carpentry: Wood sizing exercise in planning, marking, sawing, chiselling and grooving to make
1. Tee through Halving Joint
2. Dovetail Scarf Joint
Fitting: Preparation of joints, markings, cutting and filling for making
1. Semi-circle part
2. Dovetail part
Sheet metal: Fabrication of simple products of the following
1. Dust Pan
2. Corner Tray

Text Books:

1 R.K. Rajput, "Workshop Practice", Laxmi Publications (P) Limited

2 Shashi Kant Yadav, "Workshop Practice", Discovery Publishing House, New Delhi.

3 K.C.John, "Mechanical workshop practice" PHI Learning Pvt. Ltd., (2010).

SECOND SEMESTER

Course Code	:	HM101
Course Title	:	**English for Communication**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1 Use the features of communication to express themselves orally in English in an intelligible way.

CO2 Develop an awareness of problems related to listening in different contexts.

CO3 Apply reading strategies to comprehend different difficulty levels in English at a speed suited to their needs.

CO4 Employ strategies to write acceptable sentences and coherent paragraph SH in English.

Course Content:

Communication: An introduction – Its role and importance in the corporate world – Tools of communication – Barriers – Levels of communication – English for Specific purposes.

Listening: Listening process & practice – Exposure to recorded & structured talks, class room lectures – Problems in comprehension & retention – Note-taking practice – Listening tests – Importance of listening in the corporate world.

Reading: Introduction of different kinds of reading materials: technical & non-technical – Different reading strategies: skimming, scanning, inferring, predicting and responding to content – Guessing from context – Note making – Vocabulary extension.

Speaking: Barriers to speaking – Building self-confidence & fluency – Conversation practice- Improving responding capacity – Extempore speech practice – Speech assessment.

Writing: Effective writing practice – Effective sentences: role of acceptability, appropriateness, brevity & clarity in writing – Cohesion & coherence in writing – Writing of definitions, descriptions & instructions – Paragraph writing – Perspective Writing – Letter Writing – Introduction to report writing

Text Books:

1 William Strunk Jr. and E.B.White “The Elements of Style”, Allyn & Bacon, Pearson Education, 1999

2 Dhanavel, S. P., “English And Communication Skills For Students Of Science And Engineering”, Orient Black Swan, Chennai, 2009.

3 Geoffrey Leech, Fan Svartvik, “A Communicative Grammar of English”, Pearson Education Asia, 1994

Reference Books:

1 Krishna Mohan and Meenakshi Raman , “Effective English Communication”, Tata McGraw Hill, New Delhi, 2000

2 Golding S.R., “Common Errors in English Language”, Macmillan, 1978. 3 Christopher Turk, “Effective Speaking”, E & FN Spon, London, 1985

Web link(s):

1 Communication - https://nptel.ac.in/courses/109/104/109104031/

2 Listening - https://learnenglish.britishcouncil.org/skills/listening/

http://www.elllo.org/archive/

3 Speaking - https://nptel.ac.in/courses/109/106/109106067/

4 Reading & Vocabulary - https://nptel.ac.in/courses/109/106/109106129/ (Week 1 & 2)

5 Writing - https://www.time4writing.com/free-writing-resources/

https://www.edx.org/course/academic-and-business-writing/

https://www.coursera.org/learn/advanced-writing/

Course Code	:	MA151
Course Title	:	**Mathematics - II**
Number of Credits	:	3
Prerequisites (Course Code)	:	**Mathematics – I**
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1 Apply the concepts of gradient, divergence, and curl to solve engineering problems

CO2 Convert line integrals into area integrals and surface integrals into volume integrals

CO3 Determine the Fourier series for a given function

CO4 Change the given function into transform coefficients using Fourier transformation.

CO5 Apply Laplace transforms to solve physical problems arising in engineering

Course Content:

Vector Calculus: Scalar and Vector fields - Vector Differentiation - Level surfaces - Directional derivative - Gradient of a scalar field - Divergence and Curl of a vector field – Laplacian.

Vector Integrals: Line, surface and volume integrals; Green's theorem in a plane - Gauss Divergence theorem and Stokes' theorem.

Fourier Series: Expansion of a function in Fourier series for a given range - Half range sine and cosine expansions

Fourier Transforms: Complex form of Fourier series -Fourier transformation and inverse transforms - sine, cosine transformations and inverse transforms - simple illustrations.

Laplace Transformation: Laplace transform - Inverse Laplace transform - properties of Laplace transforms - Laplace transforms of unit step function, impulse function and periodic function - Convolution theorem - Solution of ordinary differential equations with constant coefficients and system of linear differential equations with constant coefficients using Laplace transform – Applications to electrical circuits.

Text Books:

1 Erwin Kreyszig, "Advanced Engineering Mathematics", 8th edition, John Wiley and Sons, 2015.

2 R. K. Jain and S. R. K. Iyengar, “Advanced Engineering Mathematics”, 5th edition, Narosa Publishing House, 2016.

Reference Books:

1 B.S. Grewal, “Higher Engineering Mathematics”, Khanna Publications, 44nd ed, 2015

2 Michael D. Greenberg, “Advanced Engineering Mathematics”, Pearson Education Pvt. Ltd.

Web link(s):

1 https://nptel.ac.in/courses/111/105/111105122/

2 https://nptel.ac.in/courses/111/102/111102129/

Course Code	:	PH101
Course Title	:	**Physics**
Number of Credits	:	3
Prerequisites (Course Code)	:	None
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1 Define the basic principles of thermodynamics and its significance.

CO2 Describe electromagnetic theory in the field of signal propagation.

CO3 Interpret various concepts and theories of waves and quantum optics.

CO4 Explain the principle of light transmission in a fiber for modern communication.

CO5 Apply the concepts of semiconductor physics in solid state electronic devices and technologies.

Course Content:

Thermodynamics: Introduction to thermodynamic system, surrounding, equilibrium, heat and work, Zeroth Law of Thermodynamics, Equation of state of ideal and real gases, Internal energy, first law and its applications enthalpy, second law, reversible and irreversible processes, Carnot cycle, entropy, Maxwell's relations, Clausius-Clayperon equation, Joule-Thomson process, Clausius inequality, entropy as a property, principle of increase of entropy. Calculation of entropy change, Third law.

Electromagnetics: Gauss's Theorem of Electrostatics, Ampere's law of Magnetostatics, EMF, Ohm's Law and laws of Electromagnetic Induction, Self and Mutual induction, Concept of Displacement Current, Difference between Conduction Current and Displacement Current, Maxwell's Equations in free space and dielectric media, Propagation of Electromagnetic Waves in Free Space

Waves and Quantum Optics: Wave motion, Wave equation, Superposition of waves along same direction (equal frequency) and in perpendicular directions, Lissajous figures. Transverse waves, solution of wave equation, Theory of interference of light- Newton's rings, Diffraction, applications of Interference (colours of thin films). Diffraction, Farunhofer diffraction due to single slit, double slit and, Diffraction grating (N-slit), applications of Diffraction (List only).

Lasers and Fiber Optics: Introduction, Coherence, Spontaneous and stimulated emissions, Einstein‟s coefficients, population inversion and lasing action, laser systems: Ruby laser, HeNe Laser, semiconductor laser, Applications. Fiber Optics Introduction, numerical aperture, different types of fibres, attenuation & dispersion mechanism in optical fibers (Qualitative

only), application of optical fibres, Fiber optic communication (block diagram only).

Semiconductor Physics: Energy bands; semiconductors different types, charge carriers: electrons and holes, effective mass, doping. Carrier concentration: Fermi level, temperature

dependence of carrier concentration. Drift and diffusion of carriers: excess carriers; recombination and lifetime, Hall effect, p-n Junction: depletion region, forward and reversebias, depletion and diffusion capacitances, switching characteristics; breakdown mechanisms.

Text Books:

1 M. N. Avadhanulu and P.G. Kshirsagar, "A textBooks of Engineering Physics", S. Chand and Company, New Delhi 2009

2 R.K. Gaur and S.L. Gupta, "Engineering Physics",Dhanpat Rai Publications (P) Ltd., 8th ed., New Delhi 2001.

3 R. K. Rajput, "A TextBooks of Engineering Thermodynamics" 4th Edition, L.B. Enterprizes, New Delhi 2010.

Reference Books:

1 Halliday, Resnic and Walker, "Fundamentals of Physics", John Wiley, 9 th Edition, 2011.

2 David J. GriffitSH, "Introduction to Electrodynamics", 3rd Edition, Printice Hall of India, New Delhi 2012.

3 Donald A. Neamen, "Semiconductor Physics and Devices: Basic principle", 4th Edition,, McGraw- Hill, New York 2012

Course Code	:	CS151
Course Title	:	**Introduction to python programming**
Number of Credits	:	3 (2T+2L)
Prerequisites (Course Code)	:	None
Course Type	:	GIR

Course outcomes: After completion of the course, student will be able to:

CO1 Describe the basic data types and operations in Python programming language.

CO2 Explain the various conditional control statements and string manipulations in Python.

CO3 Discuss the advanced data types and built-in functions in Python.

CO4 Develop python programs for simple graphical applications.

CO5 Construct simple web applications using Django

Course Content:

Introducing Programming: Concepts of datatypes, operations Conceptual introduction: topics in computer science, algorithms; modern computer systems: hardware architecture, data representation in computers, software and operating system; installing Python; basic syntax, interactive shell, editing, saving, and running a script. The concept of data types; variables, assignments; immutable variables; numerical types; arithmetic operators and expressions; comments in the program; understanding error messages; Conditions, boolean logic, logical operators; ranges

Loops, strings, text: Control statements: if-else, loops (for, while); short-circuit (lazy) evaluation Strings and text files; manipulating files and directories, os and sys modules; text files: reading/writing text and numbers from/to a file; creating and reading a formatted file (csv or tab-separated). String manipulations: subscript operator, indexing, slicing a string; strings and number system: converting strings to numbers and vice versa. Binary, octal, hexadecimal numbers

Datatypes: Lists, tuples, and dictionaries; basic list operators, replacing, inserting, removing an element; searching and sorting lists; dictionary literals, adding and removing keys, accessing and replacing values; traversing dictionaries. Design with functions: hiding redundancy, complexity; arguments and return values; formal vs actual arguments, named arguments. Program structure and design. Recursive functions.

Graphics, images, classes and OOPs: Simple Graphics and Image Processing: turtle module; simple 2d drawing - colors, shapes; digital images, image file formats, image processing. Simple image manipulations with 'image' module (convert to bw, greyscale, blur, etc). Classes and OOP: classes, objects, attributes and methods; defining classes; design with classes,

data modeling; persistent storage of objects OOP, continued: inheritance, polymorphism, operator overloading (eq _, str, etc); abstract classes; exception handling, try block

Multithreading, Web development: Multithreading in Python. Concurrent threads, applications, examples. Web development; introduction to HTML, introduction to Django, models, templates, forms etc.

Text Books:

1 Kenneth Lambert, "Fundamentals of Python: First Programs", Course Technology, Cengage Learning, 2012, ISBN-13: 978-1-111-82270-5

2 Swaroop, H. "A Byte of Python". Independent, 2013. ISBN: 9781365042911

3 Pilgrim, Mark, and Simon Willison. "Dive Into Python 3". Vol. 2. Apress, 2009. ISBN: 9786612825347

Reference Books:

1 Beazley, David M. "Python essential reference". Addison-Wesley Professional, 2009. ISBN: 0672329786

2 Beazley, David, and Brian K. Jones. "Python CookBooks: Recipes for Mastering Python 3". O'Reilly Media, Inc., 2013

3 George, Nigel. "Beginning django CMS". Apress, 2015. ISBN: 978-1-4842-1669-9

Web link(s):

1 https://python.swaroopch.com/

2 https://goalkicker.com/PythonBooks/PythonNotesForProfessionals.pdf

3 https://www.w3schools.com/python/

4 https://diveintopython3.problemsolving.io/

5 https://docs.djangoproject.com/en/3.0/intro/tutorial01/

6 https://docs.python.org/3/

Course Code	:	EC152
Course Title	:	**Digital Principles and System Design**
Number of Credits	:	3
Prerequisites (Course Code)	:	None
Course Type	:	PC

Course outcomes: After completion of the course, student will be able to:

CO1 Review number systems and Boolean algebra.

CO2 Design combinational circuits with basic logic gates.

CO3 Devise sequential logic circuits with basic logic gates.

CO4 Analyze synchronous circuit using state diagrams based on Moore and Mealy configurations.

CO5 Develop Verilog HDL program for combinational and sequential logic circuits.

Course Content:

Review of number systems-representation-conversions, error detection and error correction. Review of Boolean algebra- theorems, sum of product and product of sum simplification, canonical forms-minterm and maxterm, Simplification of Boolean expressions-Karnaugh map, completely and incompletely specified functions, Implementation of Boolean expressions using universal gates.

Combinational logic circuits- adders, subtractors, BCD adder, ripple carry look ahead adders, parity generator, decoders, encoders, multiplexers, demultiplexers, Realization of Boolean expressions- using decoders-using multiplexers. Memories – ROM- organization, expansion. PROMs. Types of RAMs – Basic structure, organization, Static and dynamic RAMs, PLDs, PLAs.

Sequential circuits – latches, flip flops, edge triggering, asynchronous inputs. Shift registers, Universal shift register, applications. Binary counters – Synchronous and asynchronous up/down counters, mod-N counter, Counters for random sequence.

Synchronous circuit analysis and design: structure and operation, analysis-transition equations, state tables and state diagrams, Modelling- Moore machine and Mealy machine- serial binary adder, sequence recognizer, state table reduction, state assignment. Hazard; Overview and comparison of logic families.

Introduction to Verilog HDL, Structural, Dataflow and behavioral modelling of combinational and sequential logic circuits.

Text Books:

1 D. D. Givone, “Digital Principles and Design”, Tata Mc-Graw Hill, New Delhi, 2003.

2 Wakerly J F, “Digital Design: Principles and Practices, Prentice-Hall”, 2nd Ed., 2002.

3 S.Brown and Z.Vranesic, “Fundamentals of Digital Logic with Verilog Design”, Tata Mc-Graw Hill, 2008.

Reference Books:

1 M. M. Mano, “Digital Design”, 3rd ed., Pearson Education, Delhi, 2003.

2 D.P. Leach, A. P. Malvino, GoutamGuha, “Digital Principles and Applications”, Tata Mc-Graw Hill, New Delhi, 2011.

3 R.J.Tocci and N.S.Widner, “Digital Systems - Principles& Applications”, PHI, 10th Ed., 2007.

Web link(s):

1 https://nptel.ac.in/courses/108/105/108105132/ (NPTEL Video by Prof. Gautam Saha from IIT Kharagpur)

2 https://nptel.ac.in/courses/108/105/108105113/ (NPTEL Video by Prof.Santanu from IIT Kharagpur)

Course Code	:	EC153
Course Title	:	**Solid-State Devices**
Number of Credits	:	3
Prerequisites (Course Code)	:	None
Course Type	:	PC

Course outcomes: At the end of the course, the student will be able to:

CO1 Illustrate the importance of four major building blocks of semiconductor devices.

CO2 Discuss the physics behind the parameters of a semiconductor device model.

CO3 Explain the transient and ac behavior of P-N junction.

CO4 Design basic amplifier and logic switches using semiconductor devices.

CO5 Describe the operations of MOSFET.

Course Content:

Semiconductors. Energy band formation in solids: charge carriers, intrinsic, extrinsic semiconductors, and effective mass. Equilibrium Carrier concentration: Fermi-Dirac statistics, charge neutrality.

Carrier transport: conductivity, Drift, Diffusion, G-R, continuity equation, Hall effect and its applications. Temperature effects. Excess carriers: optical absorption.

P-N junction: equilibrium conditions, biasing, diode models, steady-state, transient and ac behavior. Temperature effects. Break down mechanisms, applications and types of diodes. Metal-semiconductor junctions.

BJT Physics and modes of operation, threshold, biasing, BJT models, I-V characteristics, BJT as a switch and amplifier, breakdown mechanisms, non-ideal and thermal effects.

MOS capacitor: ideal and non-ideal, C-V characteristics. MOSFET: operation, models, ideal I-V characteristics, non-ideal effects, scaling, SCE introduction. Other FET devices, BiCMOS logic. Basics of semiconductor fabrication process.

Text Books:

1 Ben G Streetman, S Banerjee, “Solid state electronic devices”, (4/e) Prentice hall, 1995

2 S M Sze, “Semiconductors Devices: Physics and Technology”, (2/e), Wiley, 2002

3 M S Tyagi, “Introduction to semiconductor materials and devices”, John Wiley, 2008

Reference Books:

1 C T Sah, “Fundamentals of solid state electronics”, World Scientific Publication, 1991.

2 Y Taur and T H Ning, “Fundamentals of modern VLSI devices”, Cambridge university press, 2013.

3 Robert Pierret, “Semiconductor Device Fundamentals,” Pearson Education, 1996

Web link(s):

1 https://nptel.ac.in/courses/117/106/117106091/ (NPTEL lecture on Sold-State Devices by Prof. Karmalkar, IIT Madras)

2 https://nanohub.org/courses/PSF/fall2018 (Purdue University lecture on Semiconductor Fundamentals by Prof. Mark Lundstrom)

Course Code	:	ME152
Course Title	:	**Energy and Environmental Engineering**
Number of Credits	:	0
Prerequisites (Course Code)	:	None
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1 Examine the impact of various types of pollution.

CO2 Discuss the methods used for waste management.

CO3 Analyze the demand for solar and thermal energy.

CO4 Identify the alternative energy resources that reduce pollution.

CO5 Evaluate the engineering applications for agriculture and irrigation.

Course Content:

Pollution: Air pollution - Sources, effects, control, air quality standards -Air pollution act, air pollution measurement. Water pollution-Sources, impacts, control, and measure –Quality of water for various purposes-Noise pollution - Sources, impacts, control, measure.

Waste Management: Pollution aspects of various industries- Impacts of fossil fuels and transport emissions – impacts - Municipal solid waste generation and management - Swachh Bharat Mission – E-waste management - Challenges and activities - Environment and forest conservation – Greenhouse gases and global warming- climate change.

Solar and Thermal Energy: Present energy resources in India and its sustainability - Different types of conventional power plants -Energy demand scenario in India - Advantage and disadvantage of conventional Power Plants – Conventional vs. non-conventional power generation - Basics of Solar Energy, Solar thermal and Solar photovoltaic systems.

Wind and Geo Thermal Energy: Power and energy from wind turbines -Types of wind turbines-Biomass resources Biomass conversion technologies- Feedstock pre-processing and treatment methods Introduction to geothermal energy and tidal energy.

Agriculture Engineering: Introduction to agriculture engineering -Major crops of India–Types and categories of Crops-Types of farming and cultivation procedures-Different monsoon seasons-Types of irrigation systems-Major draughts-Agricultural machinery-Dairy farming and its economic importance

Text Books:

1 B. H. Khan, “Non-Conventional Energy Resources”, The McGraw –Hill Second Edition,

2009.

2 Gilbert M. Masters, “Introduction to Environmental Engineering and Science”, Prentice Hall, Second Edition, 2003

3 G.L. Asawa, “Elementary Irrigation Engineering”, New Age International, First Edition, 2014

Reference Books:

1 Sukhpal Singh, “Agricultural Machinery Industry in India”, Allied Publishers, New Delhi, 2010.

2 Dilip R. Shah, “Co-Operativization Liberalization and Dairy Industry in India”, A.B.D. Publishers, 2000.

3 G. Boyle, “Renewable energy: Power for a sustainable future”, Oxford University press, 2004

Course Code	:	PH102
Course Title	:	**Physics laboratory**
Number of Credits	:	2
Prerequisites (Course Code)	:	None
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the basic scientific principles of the designed experiments

CO2 Practice the theoretical concepts of physics through experiments

CO3 Demonstrate experiments through various experimental setups.

CO4 Evaluate, analyze and interpret the experimental data.

CO5 Design new devices based on scientific understanding

Course Content:

1. Wavelength of laser using diffraction grating
2. Wavelength of mercury spectrum – Spectrometer
3. Radius of curvature of lens – Newton's rings
4. Numerical aperture of an optical fiber
5. Field along the axis of a circular coil
6. Measurement of temperature using thermister
7. Thermo e.m.f by Potentionmeter

Course Code	:	EC154
Course Title	:	**Digital Principles and System Design Laboratory**
Number of Credits	:	2
Prerequisites (Course Code)	:	None
Course Type	:	ELR

Course outcomes: After completion of the course, student will be able to:

CO1 Validate the Boolean laws using digital ICs.

CO2 Develop logic circuit for combinational circuits and assess the functions using ICs.

CO3 Perform logic shifting for sequential circuits and test the functions using ICs.

CO4 Evaluate logic level counting for sequential circuits using flipflops.

CO5 Demonstrate the implementation of digital circuits using Verilog HDL.

List of Experiments:

1. Study of logic gates and verification of Boolean Laws.
2. Design of adders and subtractors.
3. Design of code converters.
4. Design of Multiplexers.
5. Design of De-multiplexers.
6. Design of Encoder and Decoder.
7. 2-bit and 8-bit magnitude comparators.
8. Design of flip-flops.
9. Design and implementation of counters using flip-flops.
10. Design and implementation of shift registers.
11. Implementation of digital circuits using Verilog HDL

THIRD SEMESTER

Course Code	:	MA201
Course Title	:	**Mathematics – III**
Number of Credits	:	3
Prerequisites (Course Code)	:	**Mathematics - II**
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1 Apply the Z- transform for a given sequence.

CO2 Determine the solution of a PDE by variable separable method

CO3 Calculate the series solutions for ordinary differential equations and analyze improper integrals

CO4 Transform a region to another region using conformal mapping

CO5 Evaluate real integrals using residue theorem

Course Content:

Z-transforms : Z- transform and Inverse Z-transforms – Properties – convolution theorem-simple illustrations.

Partial Differential Equations: Method of separation of variables - Solution of one dimensional wave equation, one dimensional heat conduction equation and two dimensional steady state heat conduction equation with illustrations to vibrating string, one dimensional unsteady heat flow and two dimensional steady state heat flow – Applications of PDE's.

Power Series & Improper Integrals: Review of Taylor's series – Series solution to differential equations – Gamma and Beta functions – properties – Evaluation of improper integrals

Complex Variables: Analytic function - Cauchy Riemann equations - Harmonic functions - Conjugate functions - complex integration - line integrals in complex plane - Cauchy's theorem (without proof), Cauchy's integral formula. Taylor's and Laurent's series expansions - zeros and singularities - Bilinear transformations, conformal mapping.

Residue Calculus: Residues - residue theorem, evaluation of real integrals using residue theorem.

Text Books:

1 Complex variables and its applications, R.V. Churchill, McGraw Hill, 1960.

2 Advanced Engineering Mathematics, R.K.Jain and S.R.K.Iyengar, , Narosa Pub. House, 5th ed, 2016.

3 Advanced Engineering Mathematics, Erwyn Kreyszig, John Wiley and Sons, 8th ed, 2008.

Reference Books:

1 Higher Engineering Mathematics, B.S. Grewal, Khanna Publications, 44nd ed, 2015.

2 Elements of Partial Differential Equations, I. Sneddon Tata McGraw Hill, 1972.

3 Engineering Mathematics, T.K.V. Iyengar & Others, Vol III, 9th ed, S. Chand., 2012.

4 Differential Equations, G.F. Simmons, Tata McGraw Hill, 2003.

Web link(s):

1 https://nptel.ac.in/courses/111/103/111103070/https://nptel.ac.in/courses/111/107/111107111/

https://nptel.ac.in/courses/111/103/111103021/

2 https://nptel.ac.in/courses/111/106/111106100/

Course Code	:	EC201
Course Title	:	**Electronic Circuits**
Number of Credits	:	3
Prerequisites (Course Code)	:	Network analysis and synthesis, Signals and systems, SSD
Course Type	:	PC

Course outcomes: At the end of the course, the student will be able to:

CO1 Restate and systematically analyze any basic amplifier topology.

CO2 Indicate suitable approximations in circuits to get insight over the design.

CO3 Explain constant voltage biasing and constant current biasing in amplifier design.

CO4 Describe the importance of negative feedback in designing controlled sources and gain stabilization.

CO5 Examine stability analysis of differential amplifiers.

Course Content:

Idea of power gain and need for non-linear devices. Diode: single-port non-linearity, large-signal operating point, load line, small-signal incremental model, circuit analysis with single port non-linear elements.

Two port non-linearity, amplifier constraints, BJT/MOSFET: basic regions of operation, large signal and small signal models. CE/CS amplifier: biasing, ac coupling, incremental picture, constraints on coupling capacitances and bias resistances for gain boosting. Dependence of output current on output voltage: small-signal output conductance, self-gain of CE/CS amplifier.

Constant current biasing of CE/CS amplifier: emitter/source feedback, collector/drain feedback (diode connection), current mirror bias, resistor substitution, C/D to E/S and E/S to B/G feedback using opamp.

Controlled sources using BJT/MOSFET: properties and advantages, VCVS as CC/CD amplifier (voltage buffer), CCCS as CB/CG amplifier (current buffer), CCVS as CE/CS amplifier with emitter/source degeneration (transimpedance amplifier), and VCCS (transconductance amplifier). Controlled sources using opamp: negative feedback and virtual short, VCVS and CCVS. Frequency response and swing limit of amplifiers. Cascade stages, cascode stages and active load for gain boosting.

Differential Amplifiers, CMRR, Differential amplifiers with active load, notion of single-stage and two opamp. Stability analysis, Condition for oscillation, Sinusoidal oscillators. Power amplifiers- class A, class B, class AB, Biasing circuits, class C and class D.

Text Books:

1 A S Sedra, K C Smith, “Microelectronic Circuits”, (6/e), Oxford, 2013.

2 B Razavi, “Design of Analog CMOS Integrated Circuits”, (2/e), McGraw-Hill Education, 2016.

Reference Books:

1 J Millman, A Grabel, “Microelectronics”, McGraw Hill, 1987.

2 D L Schilling, C Belove,”Electronic Circuits: Discrete and Integrated”, (3/e), McGraw Hill, 1989.

Web link(s):

1 https://nptel.ac.in/courses/108/106/108106084/(NPTEL Video by Dr.Nagendra Krishnapura from IIT Madras)

2 https://nptel.ac.in/courses/108/102/108102112/ (NPTEL Video by Prof. Souribrata Chatterji from IIT Delhi)

Course Code	:	EC202
Course Title	:	**Network Analysis & Synthesis**
Number of Credits	:	3
Prerequisites (Course Code)	:	None
Course Type	:	PC

Course Outcomes: After completion of the course, student will be able to:

CO1 Analyze the electric circuit using network theorems

CO2 Explain transient & forced response of first and second order networks.

CO3 Determine sinusoidal steady state response.

CO4 Discuss the two–port network parameters and overall response for interconnection.

CO5 Combine one port networks using Foster form, and Cauer form.

Course Content:

Network concept. Elements and sources. Kirchoff‘s laws. Tellegen‘s theorem. Network equilibrium equations. Node and Mesh method. Source superposition. Thevenin‘s and Norton‘s theorems.

First and second order networks. State equations. Transient response. Network functions. Determination of the natural frequencies and mode vectors from network functions. Millman Theorem.

Sinusoidal steady-state analysis. Maximum power-transfer theorem. Resonance. Equivalent and dual networks. Design of equalizers. Substitution Theorem.

Two-port network parameters. Interconnection of two port networks. Barlett‘s bisection theorem. Image and Iterative parameters. Design of attenuators. Network graph theory, Tree, Cutset, Incident Matrix.

Two-terminal network synthesis. Properties of Hurwitz polynomial and Positive real function. Synthesis of LC, RC and RL Networks, Foster Forms and Cauer Forms.

Text Books:

1 Hayt W. H., Kemmerly J. E. and Durbin S. M., ―Engineering Circuit Analysis, 6th Ed., Tata McGraw-Hill Publishing Company Ltd.,2008.

2 F.F. Kuo, ―Network analysis and Synthesis, Wiley International Edition, 2008.

3 Valkenberg V., ―Network Analysis, 3rd Ed., Prentice Hall International Edition, 2007

Reference Books:

1 B.S.Nair and S.R.Deepa, ―Network analysis and Synthesis, Elsevier,2012

2 Charles A Desoer, Ernest S Kuh, Basic Circuit Theory, McGraw Hill, 1969

3 G.K. Mithal and Ravi Mittal, Network Analysis, Khanna Publications, 1998

Web link(s):

1 https://nptel.ac.in/courses/108/105/108105159/ (NPTEL Video by Prof.Tapas Kumar from IIT Kharagpur)

2 https://nptel.ac.in/courses/108/102/108102042/ (NPTEL Video by Prof.S.C.Dutta Roy from IIT Delhi)

Course Code	:	EC203
Course Title	:	**Signals and Systems**
Number of Credits	:	3
Prerequisites (Course Code)	:	None
Course Type	:	PC

Course outcomes: At the end of the course, the student will be able to:

CO1 Classify the signals as Continuous time and Discrete time.

CO2 Analyze the spectral characteristics of signals using Fourier analysis.

CO3 Classify systems based on their properties and determine the response of LTI system using convolution.

CO4 Identify system properties based on impulse response and Fourier analysis.

CO5 Apply transform techniques to analyze continuous-time and discrete-time signals and systems.

Course Content:

CLASSIFICATION OF SIGNALS AND SYSTEMS: Continuous time signals (CT signals), Discrete time signals (DT signals), Step, Ramp, Impulse, Sinusoidal, Exponential, Classification of CT and DT signals - Periodic & Aperiodic signals, Deterministic & Random signals, Energy & Power signals. CT systems and DT systems: Classification of systems – Static & Dynamic, Linear & Nonlinear, Time-variant & Time-invariant, Causal & Noncausal, Stable & Unstable.

FOURIER SERIES REPRESENTATION OF PERIODIC SIGNALS: Response of LTI systems to Complex Exponentials, Fourier series Representation of CT periodic Signals, properties of CT Fourier Series, Fourier Series representation of DT periodic Signals, properties of DFS, Fourier series and LTI Systems, Filtering, Examples of CT filters, Examples of DT filters.

CONTINUOUS TIME FOURIER TRANSFORM: Representation of a periodic Signals by continuous time FT, FT of periodic signals, convolution and multiplication property of continuous time FT, systems characterized by Linear Constant Coefficient Differential Equations. TIME AND FREQUENCY CHARACTERIZATION OF SIGNALS AND SYSTEMS: Magnitude and phase representation of FT, Magnitude and phase response of LTI systems, Time domain and Frequency domain aspects of ideal and non-ideal filters. Laplace Transforms in analysis of Continuous time systems.

DISCRETE TIME FOURIER TRANSFORMS (DTFT): Properties of DTFT, convolution property, multiplication property, Duality, Systems characterized by Linear Constant Coefficient Difference Equations. SAMPLING: Sampling theorem, Impulse sampling,

sampling with zero order Hold, Reconstruction of signal from its samples using interpolation, Effect of undersampling.

Z-TRANSFORM: Z-transform, Region of convergence and its properties, Inverse Z transform,
properties of ZT, Analysis and characterization of LTI systems using ZXT, LTI Systems, System function algebra and block diagram representations.

Text Books:

1 A.V.Oppenheim, A. Willsky, S. Hamid Nawab, Signals and Systems (2/e), Pearson, 2000.

2 B. P. Lathi, Linear Systems and Signals, Oxford University Press, USA, 2004.

3 Simon Haykin, Barry Van Veen, Signals and Systems, 2nd Edition, Wiley (2002).

Reference Books:

1 Robert A. Gable, Richard A. Roberts, Signals & Linear Systems, 3_{rd} Edition, John Wiley, 1995.

2 M.J.Roberts, Signals & Systems Analysis using Transform Methods & MATLAB, Tata McGraw Hill, 2007.

3 John Alan Stuller, An Introduction to Signals and Systems, Thomson, 2007.

Web link(s):

1 https://nptel.ac.in/courses/108/106/108106075/ (NPTEL Video by Prof. V.G.K.Murti from IIT Madras)

2 https://nptel.ac.in/courses/108/104/108104100/ (NPTEL Video by Prof. Aditya from IIT Kanpur)

Course Code	:	HM251
Course Title	:	**Economics for Engineers**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1	Explain the various forms of Business and define the impact of economic variables.
CO2	Perform demand and supply analysis.
CO3	Analyze production function, cost analysis, pricing methods suitable for different market structures.
CO4	Review the elements of Financial Statements and prepare Final Accounts.
CO5	Discuss and interpret the framework for financial analysis through ratios.

Course Content:

Introduction to Business and Economics: Business: Structure of Business Firm, Theory of Firm, Types of Business Entities, Limited Liability Companies, Sources of Capital for a Company, Non-Conventional Sources of Finance. Economics: Significance, Micro and Macro Economic Concepts, Concepts and Importance of National Income, Inflation, Money Supply in Inflation, Business Cycle, Features and Phases of Business Cycle. Nature and Scope of Business Economics, Role of Business Economist, Multidisciplinary nature of Business Economics.

Demand and Supply Analysis: Demand and Supply Analysis: Determinants, Law of Demand and supply and its exceptions. Elasticity of Demand and Supply: Definition, Types, Measurement and Significance of Elasticity of Demand and Supply. Demand and Supply Forecasting, Methods of forecasting, Factors governing forecasting.

Production, Cost, Market Structures & Pricing: Production Function - Isoquants and Isocosts, MRTS, Least Cost Combination of Inputs, Cobb-Douglas Production function, Laws of Returns, Economies of Scale. Cost analysis: Concepts, Types, Short run and Long run Cost Functions, Break Even Analysis (BEA), Determination and Limitations. Market Structures: Nature of Competition and Markets, Features of Perfect competition, Monopoly, and Monopolistic Competition. Pricing: Types of Pricing, Product Life Cycle based Pricing

Financial Accounting: Financial accounting objectives, functions, importance, Accounting concepts and Conventions, Double-Entry system of Accounting, Rules for maintaining Bookss of Accounts, Journal, Posting to Ledger, Preparation of Trial Balance, Elements of Financial Statements, Preparation of Final Accounts.

Financial Analysis through Ratios: Concept of Ratio Importance, Analysis, and interpretation of Liquidity Ratios, Activity ratio, Turnover Ratios, Profitability Ratios, Proprietary Ratios, Leverage Ratios – Analysis and Interpretation (simple problems).

Text Books:

1 Dhanesh K Khatri, "Financial Accounting", Tata McGraw Hill, 2011.

2 Robert Pindyck, and Daniel Rubinfeld, "Microeconomics", 9th Edition,Pearson, 2018

3 Geethika Ghosh, Piyali Gosh, Purba Roy Choudhury, Managerial Economics, 2e, Tata McGraw Hill Education Pvt. Ltd. 2012.

Reference Books:

1 Paresh Shah, "Financial Accounting for Management", 2e, Oxford Press, 2015.

2 Lipsey & Chrystel, "Economics", Oxford University Press, 2012.

3 S. N. Maheshwari, Sunil K Maheshwari, Sharad K Maheshwari, Financial Accounting, 5e, Vikas Publications, 2013.

Web link(s):

1 https:// thenthata.web4kurd.net/mypdf/managerial-economics-and- financialanalysis

2 https://open.umn.edu/opentextBookss/textBookss/principles-of-microeconomics

Course Code	:	EC204
Course Title	:	**Data Structures and Algorithms**
Number of Credits	:	3
Prerequisites (Course Code)	:	None
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1 Compare Time Complexity and Space Complexity for algorithm.

CO2 Develop programs to implement linear data structures such as stacks, queues, linked lists, etc.

CO3 Apply the concept of trees and graph data structures in real world scenarios.

CO4 Review sorting and searching algorithms.

CO5 Decide appropriate data structure for any practical problem.

Course Content:

Introduction: Development of Algorithms - Notations and analysis - Storage structures for arrays - Sparse matrices - Stacks and Queues: Representations and applications.

Linked list, Stacks, and Queues: Linked Lists - Linked stacks and queues - Operations on polynomials - Doubly linked lists - Circularly linked lists - Dynamic storage management - Garbage collection and compaction.

Trees: Binary Trees - Binary search trees - Tree traversal - Expression manipulation - Symbol table construction - Height balanced trees – AVL trees - Red-black trees.

GrapSH: GrapSH - Representation of grapSH - BFS, DFS - Topological sort. String representation and manipulations - Pattern matching.

Sorting and Searching: Sorting Techniques - Selection, Bubble, Insertion, Merge, Heap, Quick, and Radix sort - Address calculation - Linear search - Binary search - Hash table methods.

Text Books:

1 J. P. Tremblay and P. G. Sorenson, “An Introduction to Data Structures with applications”, Second Edition, Tata McGraw Hill, 1981

2 M. Tenenbaum and Augestien, “Data Structures using C”, Third Edition, Pearson Education 2007

3 Mark Allen Weiss, “Data Structures and Algorithm Analysis in C”, 2nd edition, AddisonWesley Educational Publishers, 2006.

Reference Books:

1 Alfred V. Aho, John E. Hopcroft, Jeffrey D.Ullman, “Data Structure and Algorithms”, Second Edition, Pearson Education, 2009

2 Sara Baase and Allen Van Gelder, “Computer Algorithms - Introduction to Design and Analysis”, Third Edition, Pearson Education, 2008.

3 Sartaj Sahni, “Data Structures, Algorithms and Applications in C++”, Universities Press (I) Pvt. Ltd.

Web link(s):

1 https://courses.cs.washington.edu/courses/cse373/20sp/

2 https://nptel.ac.in/courses/106/102/106102064/

Course Code	:	EC205
Course Title	:	**Electronic Circuits Laboratory**
Number of Credits	:	2
Prerequisites(Course Code)	:	Devices and networks lab
Course Type	:	ELR

Course outcomes: At the end of the course, the student will be able to:

CO1	Illustrate stable biasing techniques for BJT and MOSFET on breadboard
CO2	Design single stage amplifiers with desired gain using BJT and MOSFET
CO3	Predict controlled sources in negative feedback ensuring stability
CO4	Interpret the frequency response of the amplifiers with respect to the circuit elements and transistor internal components
CO5	Simulate the internal circuitry of a single stage opamp

List of Experiments:

1. Quiescent Point Stabilization in BJT and MOSFET
2. Single-Stage Common-Source Amplifier
3. Single-Stage RC-Coupled Common-Emitter Amplifier
4. Unity Gain VCVS Using BJT in a Negative Feedback
5. Unity Gain CCCS Using BJT in a Negative Feedback
6. Simulating a CS/CE Amplifier with Current Mirror Bias and Active Load
7. Study on Cascade Amplifiers with MOSFET and BJT
8. Study on Cascode Amplifiers with MOSFET and BJT
9. Study on Differential Amplifier using MOSFET and BJT
10. Design and simulation of a Single-Stage Op-Amp Circuits

Course Code	:	EC206
Course Title	**:**	**Electrical Networks Laboratory**
Number of Credits	:	2
Prerequisites	:	None
Course Type	:	ELR

Course Outcomes: After the completion of the course, student will be able to:

CO1 Experiment network theorems in electric circuits.

CO2 Review responses of RL, RC and RLC circuits.

CO3 Design constant K high pass filter.

CO4 Demonstrate attenuators and equalizers.

CO5 Discuss the two–port network parameters and overall response for interconnection.

List of Experiments:

1 Node and Mesh Analysis to measure voltage and current

2 Verifications of Thevenin‘s and Norton‘s theorems

3 Response study of RL Circuit

4 Response study of RC Circuit

5 Response study of RLC Circuit

6 Constant K High pass Filter

7 Attenuators

8 Equalizers

9 Driving point and transfer functions of a two port network

10 LAB view implementation

FOURTH SEMESTER

Course Code	:	MA252
Course Title	:	**Probability and Random Processes**
Number of Credits	:	4
Prerequisites (Course Code)	:	None
Course Type	:	PC

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the axiomatic formulation of modern probability theory.

CO2 Describe probability models and functions of random variables.

CO3 Evaluate and apply moments & characteristic functions of multiple random variables.

CO4 Determine covariance and spectral density of stationary random processes.

CO5 Discuss the concept of Gaussian processes for linear systems application.

Course Content:

Sample Space and Probability: Sets, Probabilistic Models, Conditional Probability, Total Probability theorem and Baye's Rule, Independence, and Counting.

Random Variables: Probability mass functions (PMFs), Probability density functions (PDFs), Cumulative distribution functions (CDFs), Functions of random variables, Expectation and variance, Joint PMFs and PDFs of multiple random variables, Conditioning, and independence. Bernoulli, Binomial, Geometric, Poisson, Exponential, and Normal Random variables.

Multiple Random Variables: Moments, Derived distribution, Covariance and Correlation, transforms and characteristic functions, Chebyshev and Schwartz inequality, and Convergence concepts.

Random Processes – Temporal Characteristic: Concept, Stationarity and independence, Correlation functions, Gaussian random process, Bernoulli Process, Poisson random process

Random Processes – Spectral Characteristic: Power Density spectrum and its properties, Relationship between power spectrum and autocorrelation function, Cross-power density spectrum, Cross power spectrum and cross-correlation function, White and colored noise, Linear systems with random inputs.

Text Books:

1 Dimitri P. Bertsekas and John N. Tsitsiklis, Introduction to probability, Athena Scientific,

Belmount, Masschusetts, 2008.

2 Peyton Z. Peebles Jr. - Probability, Random Variables, and Random Signal Principles, McGraw-Hill, 2000.

3 Henry Stark, John W. Woods, Probability and Random Processes with Applications to Signal Processing-Prentice Hall, 2001

Reference Books:

1 Davenport, Probability and Random Processes for Scientist and Engineers, McGraw-Hill, 1970.

2 Papoulis. A, Probability Random variables and Stochastic Processes, McGraw-Hill, 2002.

3 Jim Pitman, Probability, Springer, 1993.

Web link(s):

1 https://ocw.mit.edu/resources/res-6-012-introduction-to-probability-spring-2018/

2 https://www.youtube.com/channel/UC3l1RPdC7259bQZ8JWQYdrw

Course Code	:	EC251
Course Title	:	**Embedded Systems**
Number of Credits	:	3
Prerequisites (Course code)	:	Digital principles and system design
Course Type	:	PC

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the overall landscape and characteristics of embedded systems.

CO2 Summarize the architecture and programming aspects of the embedded processor.

CO3 Develop application software for embedded systems using RTOS functions.

CO4 Review Linux capabilities and develop embedded Linux systems.

CO5 Analyze various embedded systems applications.

Course Content:

Introduction to Embedded Computing: Characteristics of Embedding Computing Applications, Concept of Real time Systems, Challenges in Embedded System Design, Design Process. Embedded System Architecture: Instruction Set Architecture, CISC and RISC instruction set architecture, Basic Embedded Processor/Microcontroller Architecture (ATOM processor, Introduction to Tiva family etc.)

Designing Embedded Computing Platform: Bus Protocols, Bus Organization, Memory Devices and their Characteristics, Memory mapped I/O, I/O Devices, I/O mapped I/O, Timers and Counters, Watchdog Timers, Interrupt Controllers, Interrupt programming, DMA Controllers, GPIO control, A/D and D/A Converters, Need of low power for embedded systems, Mixed Signals Processing

Programming Embedded Systems: Basic Features of an Operating System, Kernel Features, Real-time Kernels, Processes and Threads, Context Switching, Scheduling, Shared Memory Communication, Message-Based Communication, Real-time Memory Management, Dynamic Allocation, Device Drivers, Real-time Transactions and Files, Realtime OS (VxWorks, RT-Linux, Psos).

Network Based Embedded Applications: Embedded Networking Fundamentals, Layers and Protocols, Distributed Embedded Architectures, Internet-Enabled Systems, IoT overview and architecture, Interfacing Protocols (like UART, SPI, I2C, GPIB, FIREWIRE, USB,). Various wireless protocols and its applications: NFC, ZigBee, Bluetooth, Bluetooth Low Energy, WiFi. CAN. Overview of wireless sensor networks and design examples

Case studies: Embedded system design using ATOM processors, Galileo and Tiva based

embedded system applications.

Text Books:

1 Wayne Wolf, "Computers as Components- Principles of Embedded Computing System Design", Morgan Kaufmann Publishers, Second edition, 2008

2 C.M. Krishna, Kang G. Shin, "Real time systems", Mc- Graw Hill, 2010

3 Raj Kamal, Embedded Systems Architecture, Programming, and Design. (2/e), Tata McGraw Hill, 2008.

Reference Books:

1 Tim Wilmshurst, "The design of Small –Scale Embedded Systems, Palgrave, 2003.

2 K.V. Shibu, Introduction To Embedded Systems, Tata McGraw, 2009

3 Marwedel Peter, "Embedded System Design, Kluwer Publications, 2004

Web link(s):

1 https://swayam.gov.in/nd1_noc20_ee98/preview (SWAYAM NPTEL Video by Prof.Dhananjay from Netaji Subhas University of Technology)

2 https://nptel.ac.in/courses/106/105/106105159/(NPTEL Video by Prof. Anupam Basu from IIT Kharagpur)

Course Code	:	EC252
Course Title	:	**Analog Integrated Circuits**
Number of Credits	:	3
Prerequisites (Course Code)	:	Networks analysis, Electronic circuits
Course Type	:	PC

Course Outcomes: After the completion of the course, the student will be able to:

CO1 Describe the characteristics of op-amp and design op-amp circuits to perform arithmetic operations.

CO2 Design linear and non-linear applications using op-amps.

CO3 Apply filters and voltage regulators using functional ICs.

CO4 Evaluate the functions of timer functional ICs.

CO5 Choose appropriate A/D and D/A converters for signal processing applications.

Course Content:

Introduction to op-amps: ideal Characteristics, Pin configuration of 741 op-amp. Bias, offsets and drift, bandwidth and slew rate. Offset and Frequency compensation. Exercise problems. Practical op amps, Basic building blocks: Current sources and active loads

Linear and non-linear applications of op-amps: Inverting and non-inverting amplifiers, Applications: inverting and non- inverting summers, difference amplifier, differentiator and integrator, Voltage to current converter. Instrumentation amplifier, Log and antilog amplifiers. Precision rectifier, Non-linear function generator. Analog IC Multipliers, Comparators, Astable and Monostable multi vibrator, Wave form- generators: Triangular, and Sine-RC-phase shift oscillator, Wein's bridge oscillator

Active filters: Low pass, High pass, Band pass and Band Reject filters. IC voltage regulators: IC 723 general purpose regulator, Switching Regulator.

Timers & phase locked loops: 555 Timer functional diagram, monostable and astable operation, applications. PLL- basic block diagram and operation, capture range and lock range; applications of PLL IC 565, AM detection, FM detection and FSK demodulation. VCO IC 566.

Digital to analog and analog to digital converters: Weighted resistor DAC, R-2R and inverted R-2R DAC. Counter type ADC, successive approximation ADC, Flash ADC, dual slope ADC, sigma-Delta ADC.

Text Bookss:

1 G B Clayton, Operational Amplifiers, 5th Edition, Elsevier science, 2003

2 Sergio Franco, Design With Operational Amplifier and Analog Integrated Circuits, 4th Edition, TMH, 2011.

3 Roy Choudary D. and Shail B. Jain, Linear Integrated circuits, 4th Edition, New Age International Publishers, 2010

4 Ramakant A.Gayakward, Op-Amps and Linear Integrated Circuits, 4th Edition, PHI, 2010.

Reference Bookss:

1 Sedra and Smith, Microelectronics Circuits, Oxford Univ. Press, 2004

2 Coughlin, Driscoll, OP-AMPS and Linear Integrated Circuits, Prentice Hall, 2001.

Web link(s):

1 https://nptel.ac.in/courses/108/108/108108125/ (NPTEL Video by Prof.Hardik J Pandya from IISC Bangalore)

2 https://nptel.ac.in/courses/108/108/108108114/ (NPTEL Video by Prof.Hardik J Pandya from IISC Bangalore)

Course Code	:	EC253
Course Title	:	**Communication Theory**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	PC

Course outcomes: At the end of the course, the student will be able to:

CO1 Discuss the basics of communication system and analog modulation techniques.

CO2 Apply the basics of signals and systems to understand the concept of frequency modulation.

CO3 Determine the impact of noise in communication system.

CO4 Examine the effect of noise performance in FM systems.

CO5 Explain TDM and Pulse Modulation techniques.

Course Content:

Amplitude Modulation: Basic blocks of Communication System, Amplitude (Linear) Modulation – AM, DSB-SC, SSB and VSB, Comparison. Methods of generation and detection, Frequency division Multiplexing (FDM).

Angle Modulation: Phase and frequency modulation, Narrow Band and Wind band FM, Spectrum, FM modulation and demodulation, FM Discriminator, PLL as FM Demodulator, Transmission bandwidth. Super Heterodyne Receivers

Noise Characterization: Review of Random Process, Transmission of Random Process through an LTI filter, PSD, Properties of PSD. Gaussian Process, Noise, Narrow Band Noise, Noise Figure, Noise Bandwidth, Noise Temperature. Noise in AM Receivers, Noise DSB-SC, Noise in SSB Receivers.

Noise in FM receivers, Threshold effect, Capture effect, FM Threshold reduction, Pre-emphasis and De-emphasis.

Pulse Modulation techniques: Sampling Process, PAM, PWM and PPM concepts, Methods of generation and detection. TDM. Noise performance.

Text Books:

1 S.Haykins, Communication Systems, Wiley, 4th Edition, 2009.

2 John G. Proakis and Masoud Salehi, Communication Systems Engineering, 2nd Edition, 2001.

3 Kennedy, Davis, Electronic Communication Systems, 4th Edition, McGraw Hill, 2008.

Reference Books:

1 B.P.Lathi, "Modern Digital and Analog Communication Systems", 3rd Edition, Oxford University Press, 2007.

2 A Bruce Carlson, PB Crilly, JC Rutledge, Communication Systems, 4th Edition, McGraw Hill New York, 2002.

3 J. S. Beasley & G. M. Miler, Modern Electronic Communication, 9th Edition, Prentice-Hall, 2008.

Web link(s):

1 http://www.nptelvideos.in/2012/11/communication-engineering.html (NPTEL Video by Prof.Surendra Prasad from IIT Delhi)

2 https://nptel.ac.in/courses/117/105/117105143/ (NPTEL Video by Prof.Goutam Das From IIT Kharagpur)

Course Code	:	EC254
Course Title	:	**Control Systems**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	PC

Course outcomes: At the end of the course, the student will be able to:

CO1 Represent a complicated system in a simplified form using algebraic equations.

CO2 Employ time domain analysis to predict transient response parameters of systems.

CO3 Apply the concepts of various system stability criteria.

CO4 Illustrate different specifications of the system in frequency domain.

CO5 Design various transfer functions of digital control systems using state variable models.

Course Content:

Concepts of Control Systems- Open Loop and closed loop control systems and examples- Feedback Characteristics, Effects of feedback. Mathematical models – Differential equations, Impulse Response and transfer functions. Block diagram representation of systems considering electrical systems as examples – Representation by Signal flow graph - Reduction using mason's gain formula.

Time response of first order systems – Characteristic Equation of Feedback control systems, Transient response of second order systems – Steady state response - Steady state errors and error constants

The concept of stability – Ruth's stability criterion – qualitative stability and conditional stability – limitations of Ruth's stability. Root locus concept - construction of root loci

Frequency domain specifications-Bode diagrams- Phase margin and Gain margin - Stability Analysis from Bode Plots. Polar Plots, Nyquist Plots Stability Analysis. Compensation techniques – Lag, Lead, and Lead-Lag.

Concepts of state, state variables and state model, derivation of state models from block diagrams, Diagonalization- Solving the Time invariant state Equations- State Transition Matrix and it's Properties – Concepts of Controllability and Observability.

Text Books:

1 K. Ogata, Modern Control Engineering, (5/e), PHI, 2009.

2 B.C. Kuo, Automatic Control Systems, (9/e), PHI, 2009.

3 K. Morris, An Introduction to Feedback Control, Academic Press, 2001

Reference Books:

1 R.C. Dorf& R.H. Bishop, Modern Control Systems (8/e), Pearson, 1999.

2 M.Gopal, ―Control System – Principles and Design‖, Tata McGraw Hill, 4th Edition, 2012.

3 S.K.Bhattacharya, Control System Engineering, 3rd Edition, Pearson, 2013.

Web link(s):

1 https://nptel.ac.in/courses/107/106/107106081/ (NPTEL Video by PROF. C.S. Shankar Ram from IIT Madras)

2 https://nptel.ac.in/courses/108/106/108106098/ (NPTEL Video by Prof. Ramakrishna from IIT Madras)

Course Code	:	EC255
Course Title	:	**Computer Networks**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the architecture of network hardware and software.

CO2 Summarize the functions of Datalink layer.

CO3 Review the functions of Network layer.

CO4 Define the elements of transport layer.

CO5 Explain the functions of application layer.

Course Content:

Introductory Concepts - Network hardware - Network software – Review of Physical layer - Guided transmission media - Cable television

Data Link Layer - Design issues - Channel allocation problem - Multiple access protocols - Ethernet - Wireless LAN - 802.11 architecture

Network Layer - Design issues - Routing algorithms - Congestion control algorithms - Quality of Service - Internetworking

Transport Layer - Transport service - Elements of transport protocols - User Datagram Protocol - Transmission Control Protocol

Application Layer - DNS - Electronic mail - World Wide Web - Multimedia

Text Books:

1 Forouzan, B.A., “Data Communication and Networking”, 4th Ed., Tata McGraw-Hill,2012

2 Tanenbaum, A.S, “Computer Networks”, 4th Ed., Pearson Education,2010

3 Stallings W., “Data and Computer Communication”, 8th Ed., Prentice-Hall,2010

Reference Books:

1 Kurose, J.F. and Ross, K.W., "Computer Networking: A Top-Down Approach Featuring the

Internet", 3rd Ed., Addison Wesley.,2009

2 Comer, D.E. and Droms, R.E., “Computer Networks and Internets”, 4th Ed., Prentice-Hall.

3 LL Peterson, BS Davie, Computer Networks: A Systems Approach, 5th Ed., Morgan-Kauffman, 2011

Web link(s):

1 https://nptel.ac.in/courses/106/106/106106091/ (Prof. Sujoy Ghosh from IIT Kharagpur)

2 http://www.cs.cmu.edu/~srini/15-441/F06/syllabus.html (David Anderson from Carnegie Mellon University)

Course Code	:	EC256
Course Title	:	**Embedded Systems Laboratory**
Number of Credits	:	2
Prerequisites (Course code)	:	None
Course Type	:	ELR

Course outcomes: At the end of the course, the student will be able to:

CO1 Practice the programs in microcontroller.

CO2 Use various interfacing kits with microcontroller.

CO3 Connect various peripheral devices I/O with microcontroller.

CO4 Perform various process and scheduling in RTOS.

List of Experiments:

I Basic programming of micro controllers Study of the architecture and instruction set of popular micro controllers (8 bit, 16 bit, 32 bit processors)

1. Assembler and Embedded Programming

2. High level language programming (C, C++) and porting it on a processor

II. Interfacing experiments using microcontrollers

1. Using interrupts and interfacing clocks.

2. Interfacing peripheral devices / IO.

3. Motor speed control

III. RTOS Experiments

1. Introduction to Real-Time /Embedded Operating Systems.

2. Process Management & Inter Process Communication

3. Memory management

4. I/O subsystem

5. Real Time Scheduling

Course Code	:	EC257
Course Title	:	**Analog Integrated Circuit Laboratory**
Number of Credits	:	2
Prerequisites (Course Code)	:	Electronic circuits laboratory
Course Type	:	ELR

Course Outcomes: After the completion of the course the student will be able to:

CO1 Measure the parameters of IC741 Op-amp.

CO2 Use Op-amp to design analog filters.

CO3 Design the waveform generators using op-amp.

CO4 Develop monostable and astable multivibrators using 555 IC.

CO5 Devise voltage regulator using IC723.

List of Experiments:

1 Measurement of op-amp parameters: (i) Offset voltage, (ii) Offset current, (iii) CMRR and (iv) Slew rate

2 Frequency response of inverting and non-inverting amplifier

3 Difference amplifier, differentiator and integrator

4 Square and Triangular wave- generators

5 Oscillators

6 Analog Filters

7 Op-amp monostable and astable multivibrators

8 Low voltage regulator IC 723

9 555 Timer

10 555 timer: Monostable and astable multivibrators

11 PLL IC 565

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Course Code	:	HM301
Course Title	:	**Professional Ethics**
Number of Credits	:	0
Prerequisites (Course code)	:	None
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1 Identify the core values that shape the ethical behavior of an engineer.

CO2 Create awareness on professional ethics and Human Values.

CO3 Appreciate the rights of others.

CO4 Examine one's own ethical decision-making process.

CO5 Develop guidelines to enhance one's ability to generate solutions for conflicts.

Course Content:

Human Values: Morals, Values and Ethics – Integrity – Work Ethic – Service Learning – Civic Virtue – Respect for others – Living Peacefully – Caring – Sharing – Honesty – Courage – Valuing time – Co-operation – Commitment – Empathy – Self-confidence – Character – Spirituality – The role of engineers in modern society – Social expectations.

Engineering Ethics: Sense of 'Engineering Ethics' – Variety of moral issued – types of inquiry – moral dilemmas – moral autonomy – Kohlberg's theory – Gilligan's theory – Consensus and Controversy – Models of Professional Roles & Professionalism – theories about right action – Self-interest – customs and religion – uses of ethical theories.

Engineering as Social Experimentation: Engineering as experimentation – engineers as responsible experimenters – Research ethics – Codes of ethics – Industrial Standard – Balanced outlook on law – the challenger case study.

Safety, Responsibilities and Rights: Safety and risk – assessment of safety and risk – Risks – Risk benefit analysis and reducing risk – Govt. Regulator's approach to risks – the three mile island and Chernobyl case studies & Bhopal – Threat of Nuclear Power, depletion of ozone, greenery effects – Collegiality and loyalty – respect for authority – collective bargaining – Confidentiality – conflicts of interest – occupation crime – professional rights – employees' rights – Intellectual Property Rights (IPR) – discrimination.

Global Issues: Multinational corporations – Business ethics – Environmental ethics – computer ethics – Role in Technological Development – Weapons development – engineers as managers – consulting Engineers – engineers as expert, witnesses and advisors – Honesty – Leadership – sample code of conduct ethics like ASME, ASCE, IEEE, Institution of Engineers

(India), Indian Institute of Materials Management, Institution of Electronics and Telecommunication Engineers (IETE), India, etc.,

Text Books:

1 Mika Martin and Roland Scinger, 'Ethics in Engineeering', Pearson Education/Prentice Hall, New York 1996

2 Govindarajan M., Natarajan S., Senthil Kumar V. S., 'Engineering Ethics' Prentice Hall of India, New Delhi, 2004

3 Charles D. Fleddermann, 'Ethics in Engineering', Pearson Education/Prentice Hall, New Jersey

Reference Books:

1 Charles E. Harris, Michael S. Protchard and Michael J. Rabins, 'Engineering Ethics – Concept and Cases', Wadsworth Thompson Learning, United States, 2000 (Indian Reprint now available).

2 John R. Boatright, 'Ethics and Conduct of Business', Pearson Education, New Delhi, 2003

3 Edmund G. Seebauer and Robert L. Barry, 'Fundamentals of Ethics for Scientists and Engineers', Oxford University of Press, Oxford, 2001.

FIFTH SEMESTER

Course Code	:	EC301
Course Title	:	**Engineering Electromagnetics**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	PC

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe basic electrostatic theorems and laws and derive them.

CO2 Discuss the behavior of electric fields in matter.

CO3 Use Magnetostatics theorems and laws to infer the magnetic properties of matter.

CO4 Explain the basic theorems of electrodynamics and its derivation.

CO5 Interpret electromagnetic wave equation and wave polarization.

Course Content:

Electrostatics: Coulomb's law – Vector Form - Electric Field Intensity - flux Density - Gauss's law and applications - Electrostatic potential - Poisson's and Laplace equations.

Electrostatic fields in matter: Electric properties of matter – Electric current – Current density – point form of ohm's law – continuity equation for current. Dielectrics and dielectric polarization - Capacitors with dielectric substrates - Boundary conditions for electric fields - Force and energy in dielectric systems.

Magnetostatics: Magnetic fields of steady currents -Biot- Savart's and Ampere's laws and simple applications - Magnetic flux density, Inductance of loops and solenoids, The Lorentz force equation for a moving charge and applications – Magnetic moment – Magnetic vector potential - Magnetic boundary conditions, Magnetic properties of matter.

Electrodynamics: Flux rule for motional emf - Faraday's law - Self and mutual inductances - Maxwell's equations in integral form and differential form - Poynting theorem -Poynting Vector

Electromagnetic wave propagation: Wave Equation -Uniform plane waves - Reflection and refraction - Wave polarization –types - Dependence on Polarization - Brewster angle.

Text Books:

1 Hayt,WH. And Buck,J.A.,"EngineeringElectromagnetics",7thEdition,TMH, 2009

2 D.J. GriffitSH, Introduction to Electrodynamics (4/e), Addison-Wesley, 2012

3 E.C. Jordan & K.G. Balmain "Electromagnetic Waves and Radiating Systems" PHI Learning, 2ndedition 2011

Reference Books:

1 J.D.Krauss, "Electromagnetics", Fourth edition ,McGraw Hill,1999

2 MathewN.O.Sadiku,"ElementsofEngineeringElectromagnetics",5thEdition, Oxford University Press , 2009.

3 Narayana Rao, N., "Elements of Engineering Electromagnetics", 6th Edition, Pearson Education, 2009.

Web link(s):

1 https://swayam.gov.in/nd1_noc20_ee93/preview (SWAYAM Video by Prof.Pradeep Kumar from IIT Kanpur)

2 https://www.coursera.org/learn/electrodynamics-introduction (Course from Coursera by Seungbum Hong from KAIST)

Course Code	:	EC302
Course Title	:	**Antenna and Wave Propagation**
Number of Credits	:	3
Prerequisites (Course code)	:	Engineering Electromagnetics
Course Type	:	PC

Course outcomes: At the end of the course, the student will be able to:

CO1 Apply electromagnetic theory and fundamentals to estimate antenna parameters.

CO2 Analyze the characteristics of receiving antenna and linear antennas.

CO3 Assess the need for antenna arrays and mathematically analyze the types of antenna arrays.

CO4 Distinguish primary from secondary antennas and analyze their characteristics.

CO5 Review the factors involved in the propagation of radio waves using practical antennas.

Course Content:

Antenna Fundamentals: Introduction to antennas & its significance, Scalar electric potential, vector magnetic potential, radiation from an alternating current element, Induction field, radiation field, power radiated by a current element, Definition of electric dipole, radiation by a half wave dipole. Power by a half wave dipole & its radiation resistance, Radiation from a quarter wave monopole Power radiation and radiation resistance of dipole & monopole (approximate analysis), Radiation resistance of aerials and loop, problems Isotropic radiator, network theorem, application of network theorem to antennas

Antenna Parameters: Radiation pattern, power pattern, field pattern Radiation intensity, Antenna impedance, mutual impedance, gain and directivity, bandwidth, Polarization, efficiency, effective length, area or aperture, scattering loss, Collecting aperture, physical aperture-relation between large aperture and gain Effective aperture of a small elementary dipole, half wave antenna, effective length, front to back ratio, Antenna beam width and side lobes. Friss Transmission formula, Radar range equation

Antenna arrays - Array factorization - Array parameters - Broad side and end fire arrays - Yagi-Uda arrays - Log-periodic arrays

Aperture antenna - Fields as sources of radiation - slot antenna - Horn antennas - Babinet‟s principle - Parabolic reflector antenna – lens antenna-Phased array antennas, Smart antennas – switched beam and adaptive arrays-UWB antennas- RFID Antennas- Wearable antennas- Reconfigurable antennas.

Antenna Measurements: Radiation pattern measurements Measurement of antenna beam

width and gain, Polarization measurements. Measurement of radiation resistance-Measurement of S parameter, Anechoic chamber- Wave Propagation: Types of wave propagation, space wave propagation and line of sight distance for flat and curved surfaces

Text Books:

1 John D. Kraus, Antennas, 5nd Edition, McGraw Hill, 2017

2 Constantine.A.Balanis"Antenna Theory Analysis and Design" Wiley student edition,2006

3 Rajeswari Chatterjee,:"Antenna Theory and Practice"Revised Second edition"New Age international Publishers,2006

Reference Books:

1 S.Drabowitch,"Modern Antennas" Second edition,Springer Publications,2007

2 Robert S.Elliott"Antenna theory and Design"Wiley student edition,2006

3 Annaprna Das, Sisir K Das, "Antenna and wave propagation" Mcgraw Hill, 2012

Web link(s):

1 https://swayam.gov.in/nd1_noc20_ee20/preview (SWAYAM Video by Prof. Girish Kumar from IIT Bombay)

2 https://nptel.ac.in/courses/117/107/117107035/(NPTEL Video by Dr. Amalendu Patnaik from IIT Roorkee)

Course Code	:	EC303
Course Title	:	**VLSI System Design**
Number of Credits	:	3
Prerequisites (Course code)	:	Digital Principles, SSD
Course Type	:	PC

Course outcomes: At the end of the course, the student will be able to:

CO1 Define the fabrication, operation and characteristics of MOSFET.

CO2 Analyze the performance of CMOS inverter.

CO3 Design digital circuits using CMOS gates.

CO4 Discuss the characteristics of VLSI circuits such as area, speed and power dissipation.

CO5 Explain the importance of placement, floorplan, and routing in VLSI circuits.

Course Content:

Unit process steps of CMOS technology and Fabrication process flow. Structure and operation of the MOS transistor, I-V and C-V characteristics, MOSFET capacitances, layout, design rules, stick diagram. Scaling and Short channel effects.

Inverters with resistive, MOSFET load; CMOS inverter: Voltage transfer characteristics, Noise margins, switching characteristics, calculation of delay times; effect of load on switching characteristics and driving large loads, logical effort of patSH

Pseudo NMOS, Pass transistor, transmission gates, Dynamic logic, Domino logic, Differential cascode voltage switch logic, design of combinational circuits, design of sequential circuits, timing requirements.

Introduction to hardware description language (HDL) Verilog/VHDL. A logic synthesis example. Introduction to VLSI Design, Different types of VLSI design styles: Full custom, standard cell based, gate array based, programmable logic, field programmable gate arrays etc. Implementation of PLD, EPROM, EEPROM, static and dynamic RAM in CMOS.

Floor-planning and Placement: I/O and power planning, clock planning. Routing: global and detailed. Example design technique: mapping of architecture to silicon

Text Books:

1 D.A. Pucknell and K. Eshraghian, Basic VLSI Design, PHI Learning Private Limited, 2013.

2 N.H.E. Weste, D. Harris and A. Banerjee, CMOS VLSI Design: A Circuits and Systems Perspective, Third Edition, Pearson, 2006.

Reference Books:

1 Wayne Wolf, "FPGA-Based System Design", First Edition, Prentice Hall India Private Limited, 2004.

2 M.J.S. Smith, Application Specific Integrated Circuits, Addison-Wesley Pub. Co., 1997.

3 Samir Palnitkar, "Verilog HDL", First Edition, Prentice Hall India Private Limited, 2003.

Web link(s):

1 https://nptel.ac.in/courses/117/101/117101058/ (NPTEL Video by Prof. A.N. Chandorkar from IIT Bombay)

2 https://nptel.ac.in/courses/108/106/108106158/ (NPTEL Video by Prof.Janakiraman from IIT Madras)

Course Code	:	EC304
Course Title	:	**Digital Communication**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	PC

Course outcomes: At the end of the course, the student will be able to:

CO1 Convert analog signals into digital signals using PCM.

CO2 Compute probability of error and inter symbol interference from eye diagram in data transmission.

CO3 Explain the power spectra of digital modulated signals.

CO4 Describe various digital demodulation schemes.

CO5 Design encoder and decoder schemes for error control.

Course Content:

Digital Representation of Analog Signals: Introduction, Analog communications versus digital communications, Pulse code modulation (PCM), Differential Pulse code modulation (DPCM), Delta modulation (DM), Adaptive delta modulation (ADM), Quantization Noise in PCM and DM.

Baseband Transmission: Properties of Line codes, Power spectral density of unipolar / polar RZ & NRZ, Bipolar NRZ, Manchester. ISI, Nyquist criterion for distortionless transmission, Pulse shaping, Correlative coding, Mary schemes, Eye pattern, Equalization.

Digital Modulation Scheme: Geometric Representation of signals, Binary baseband digital modulation, M-ary baseband digital modulation. Passband Modulation: Amplitude shift keying (ASK), Frequency shift keying (ASK), Phase shift keying (PSK), Quadrature phase shift keying (QPSK), Offset-QPSK, Minimum Shift Keying (MSK), Passband waveforms for M-ary signaling, Passband modulations for band limited channels.

Digital Demodulation Scheme: Matched filters, Correlation Receivers, Coherent demodulation of binary waveforms, noncoherent demodulation of binary waveforms, Rayleigh and Ricean probability distributions, Error rates of non-coherent signaling, Demodulators for M-ary orthogonal signaling, Error rates for M-ary orthogonal signaling.

Information Theory And Error Control Coding: Introduction to information theory, Source coding, Error free communication over a noisy channel, the concept of channel capacity. Channel coding theorem, Linear Block codes, Hamming codes, Cyclic codes, Convolutional codes, Vitterbi Decoder.

Text Books:

1 Richard E. Blahut, Modem Theory An Introduction to Telecommunications, Cambridge University Press, 2009

2 S. Haykin, Digital Communications, John Wiley, 2005.

3 J.G Proakis, Digital Communication, 4th Edition, Tata Mc Graw Hill Company, 2001.

Reference Books:

1 B. Sklar, Digital Communication Fundamentals and Applications, 2nd Edition, Pearson Education, 2009

2 B.P.Lathi, Modern Digital and Analog Communication Systems, 3rd Edition, Oxford University Press, 2007.

3 Amos Lapidoth, "A Foundation in Digital Communications," Cambridge University Press, 2009.

Web link(s):

1 https://nptel.ac.in/courses/108/102/108102096/ (NPTEL Video by Prof. Surendra Prasad from IIT Delhi)

2 https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-450-principles-of-digital-communications-i-fall-2006/video-lectures/

Course Code	:	EC305
Course Title	:	**Digital Communication Laboratory**
Number of Credits	:	2
Prerequisites (Course code)	:	None
Course Type	:	ELR

Course outcomes: At the end of the course, the student will be able to :

CO1	Practice AM modulation and demodulation to evaluate their performance.
CO2	Determine sampling rates to reconstruct the signals through signal sampling.
CO3	Produce digital modulation signals for ASK, PSK and FSK using soft tool and evaluate their performance.
CO4	Simulate MSK, DPSK, QPSK and DEPSK schemes and estimate their BER.
CO5	Demonstrate wireless communication system using Wi-Comm Kit.

List of Experiments:

1. AM Modulation and Demodulation
2. DSB-SC Modulation
3. Pulse Amplitude Modulation and Demodulation
4. Pulse Width Modulation and Demodulation
5. Pulse Position Modulation using PLL(IC 565)
6. Amplitude Shift Keying (ASK) Modulation and Demodulation
7. Frequency Shift Keying (FSK) Modulation and Demodulation
8. Frequency Multiplier using PLL
9. Analog and digital modulation using COMMSIM simulation tool
10. Analog and digital modulation using MATLAB
11. Study of wireless communication system using Wi-Comm Kit

Course Code	:	EC306
Course Title	:	**VLSI Systems Laboratory**
Number of Credits	:	2
Prerequisites (Course code)	:	Digital Principles
Course Type	:	ELR

Course outcomes: At the end of the course, the student will be able to :

CO1 Practice the concepts of combinational and sequential logic circuits using HDL.

CO2 Compare the advantages of structural, behavioral, and data-flow models of HDL for different logic circuits.

CO3 Explain the RTL generated for non-structural modeling logic circuits.

CO4 Interpret the auto-generated layout from the tool for the implemented logic design.

CO5 Illustrate the differences between power-delay-aware design and conventional design.

List of Experiments:

1. Adders and subtractors
2. Mux & Demux
3. Encoders & Decoders
4. Flip-Flops
5. Shift-Registers
6. Working with RAM
7. Comparators, parity generators & ALU
8. Counters
9. Carry look ahead adder
10. Multipliers

SIXTH SEMESTER

Course Code	:	EC351
Course Title	:	**Digital Signal Processing**
Number of Credits	:	3
Prerequisites (Course code)	:	Signals and Systems
Course Type	:	PC

Course outcomes: At the end of the course, the student will be able to:

CO1 Calculate DFT of a given signal through Fast Fourier Transform Techniques.

CO2 Design FIR and IIR type digital filters.

CO3 Identify filter structures and evaluate the coefficient quantization effects.

CO4 Discuss sample rate conversion techniques.

CO5 Compare the architectures of DSP and General Purpose Processors.

Course Content:

Discrete Fourier Transform: Discrete Signals and Systems, A Review, Introduction to DFT, Properties of DFT, Circular Convolution, Filtering methods based on DFT, FFT Algorithms, Decimation in time Algorithms, Decimation in frequency Algorithms, Use of FFT in Linear Filtering.

IIR Filter Design: Structures of IIR, Analog filter design, Discrete time IIR filter from analog filter, IIR filter design by Impulse Invariance, Bilinear transformation, Approximation of derivatives (LPF, HPF, BPF, BRF) filter design using frequency translation.

FIR Filter Design: Structures of FIR, Linear phase FIR filter, Fourier Series, Filter design using windowing techniques (Rectangular Window, Hamming Window, Hanning Window), Frequency sampling techniques, Finite word length effects in digital Filters, Errors, Limit Cycle, Noise Power Spectrum.

Multirate Digital Signal Processing: Decimation by a factor D, Interpolation by a factor I, Sampling rate conversion by a rational factor I/D.

DSP Processors: TMS 320X/ ADSP 21XX Architecture and Applications.

Text Books:

1 J. G. Proakis & D. G. Manolakis, Digital Signal Processing, Principles, algorithms &

Applications, PHI, 2000.

2 S. K. Mitra, Digital Signal Processing – A computer Based Approach, 2nd Edition, MGH, 2001.

3 Reference Manuals of Texas TMS 320X and Analog Devices 21XX Processors

Reference Books:

1 Emmanuel C. Ifeachor, & Barrie. W. Jervis, Digital Signal Processing, Second Edition, Pearson Education Prentice Hall, 2002.

2 A. V. Oppenheim, R. W. Schafer and J. R. Buck, Discrete-Time Signal Processing, 8th Indian Reprint, Pearson, 2004.

3 Andreas Antoniou, Digital Signal Processing, Tata Mc Graw Hill, 2006.

Web link(s):

1 https://nptel.ac.in/courses/117/102/117102060/ (NPTEL Video by Prof. S.C.Dutta Roy from IIT Delhi)

2 https://nptel.ac.in/courses/108/106/108106151/ (NPTEL Video by Prof.C.S.Ramalingam from IIT Madras)

Course Code	:	EC352
Course Title	:	**Optical Communication**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	PC

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the propagation of signal through Fiber cable.

CO2 Describe the various modes of propagation and its importance.

CO3 Illustrate the functions of optical sources and detectors.

CO4 Discuss the implementation of fiber optic systems.

CO5 Summarize the functions of optical networks.

Course Content:

Introduction: Ray theory transmission- Total internal reflection-Acceptance angle –Numerical aperture – Skew rays – Electromagnetic mode theory of optical propagation –EM waves – modes in Planar guide – phase and group velocity – cylindrical fibers –SM fibers

Transmission characteristics of optical fibers: Attenuation – Material absorption losses in silica glass fibers – Linear and Non linear Scattering losses - Fiber Bend losses –Intra and inter Modal Dispersion – Polarization. Optical fiber connectors, Fiber alignment and Joint Losses – Fiber Splices– Fiber connectors – Expanded Beam Connectors – Fiber Couplers.

Sources and Detectors Optical sources: Light Emitting Diodes - LED structures - surface and edge emitters, internal - quantum efficiency, injection laser diode structures - comparison of LED and ILD Optical Detectors: PIN Photo detectors, Avalanche photo diodes, construction, characteristics and properties.

Fiber Optic Receiver and Measurements : Fundamental receiver operation, Pre amplifiers, Error sources – Receiver Configuration – Probability of Error – Quantum limit. Fiber Attenuation measurements- Dispersion measurements – Fiber Refractive index profile measurements – Fiber cut- off Wave length Measurements – Fiber numerical Aperture Measurements – Fiber diameter measurements.

Optical Networks: Basic Networks – SONET / SDH – Broadcast – and –select WDM Networks –Wavelength Routed Networks – Non linear effects on Network performance – Performance of WDM , EDFA system – Solitons – Optical CDMA – Ultra High Capacity Networks.

Text Books:

1 G. Keiser, Optical Fiber Communications (4/e), TMH, 2008

2 G.P. Agrawal, Fiber Optic Communication Systems, (3/e), Wiley, 2002.

3 MMK. Liu, Principles and Applications of Optical Communications, TMH, 2010

Reference Books:

1 J. Gowar, Optical Communication Systems, (2/e), PHI, 2001

2 A.Ghatak & K.Thygarajan, "Introduction to Fiber Optics", Cambridge, 1999

3 M. Sathish Kumar, "Fundamentals of optical fibre communication" PHI,2014

Web link(s):

1 https://www.coursera.org/specializations/optical-engineering? (Course from Cousera by Amy Sullivan & Robert McLeod from Colorado University)

2 https://swayam.gov.in/nd1_noc20_ee48/preview (SWAYAM Video by Prof. Shanti Bhattacharya from IIT Madras)

Course Code	:	EC353
Course Title	:	**RF and Microwave Engineering**
Number of Credits	:	3
Prerequisites (Course code)	:	Networks synthesis, Electronic circuits
Course Type	:	PC

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the active & passive microwave devices & components used in Microwave communication systems.

CO2 Analyze the multi-port RF networks and RF transistor amplifiers.

CO3 Produce microwave signals and design microwave amplifiers.

CO4 Measure and analyze microwave signal and parameters.

CO5 Illustrate the use of semiconductor devices for microwave applications.

Course Content:

Review of Low frequency parameters: Impedance, Admittance, Hybrid and ABCD parameters, Different types of interconnection of Two port networks, High Frequency parameters, Formulation of S parameters, Properties of S parameters, Reciprocal and lossless Network, Transmission matrix, RF behavior of Resistors, Capacitors and Inductors.

Characteristics of Amplifiers, Amplifier power relations, Stability considerations, Stabilization Methods, Noise Figure, Constant VSWR, Broadband, High power and Multistage Amplifiers.

Impedance matching using discrete components, Two component matching Networks, Frequency response and quality factor, T and Pi Matching Networks, Microstrip Line Matching Networks.

Terminations, Attenuators, Phase shifters, Directional couplers, Hybrid Junctions, Power dividers, Circulator, Isolator, Impedance matching devices: Tuning screw, Stub and quarter wave transformers.

Crystal and Schottky diode detector and mixers, PIN diode switch, Gunn diode oscillator, IMPATT diode oscillator and amplifier, Varactor diode, Introduction to MIC.

Text Books:

1 Reinhold Ludwig and Gene Bogdanov, “RF Circuit Design: Theory and Applications”, Pearson Education Inc., 2011

2 Robert E Colin, “Foundations for Microwave Engineering”, John Wiley & Sons Inc, 2005

3 David M. Pozar, “Microwave Engineering”, Wiley India (P) Ltd, New Delhi, 2008.

Reference Books:

1 Thomas H Lee, “Planar Microwave Engineering: A Practical Guide to Theory, Measurements and Circuits”, Cambridge University Press, 2004.

2 Mathew M Radmanesh, “RF and Microwave Electronics”, Prentice Hall, 2000.

3 Annapurna Das and Sisir K Das, “Microwave Engineering”, Tata Mc Graw Hill Publishing Company Ltd, New Delhi, 2005.

Web link(s):

1 https://nptel.ac.in/courses/117/105/117105138/ (NPTEL Video by Prof. Amitabha Bhattacharya from IIT Kharagpur)

2 https://nptel.ac.in/courses/108/103/108103141/ (NPTEL Video by Prof.Ratnajith Batacharjee from IIT Guwahati)

Course Code	:	HM351
Course Title	:	**Technical English**
Number of Credits	:	2
Prerequisites (Course code)	:	NIL
Course Type	:	GIR

Course outcomes: At the end of the course, the student will be able to:

CO1 Develop competence in English for independent and effective professional communication.

CO2 Apply thinking strategies to convince people.

CO3 Evaluate the scenario and decide the suitable writing style.

CO4 Identify suitable language to persuade and to reasonably present the analysis of a situation related to his/her profession.

Course Content:

Listening: Barriers to listening: Physical & psychological – Steps to overcome them – Purposive listening practice – Active listening and anticipating the speaker – Use of technology in the professional world – Listening online – Video Lectures.

Speaking: Fluency & accuracy in speech – Positive thinking – Kinds of thinking – Improving self-expression – Tonal variations – Listener oriented speaking – Group discussion practice– Interpersonal Conversation – Developing persuasive speaking skills – Making presentation online – Organising online events

Reading: Speed reading practice – Use of extensive readers – Trans-coding: verbal and nonverbal – Analytical and critical reading practice – Introduction to ethics & values through case – Choosing study materials

Writing: Professional Correspondence – Formal letters – CV/Resume – Argument Writing – Perspectives in writing – Narrative writing – Different registers – Tone in formal writing – Report Writing – Writing SOP – Online tools to effective writing – Publishing online - Blog writing

Study Skills: Reference Skills - Use of dictionary, thesaurus etc. – Importance of contents page, cover & back pages – Bibliography – Use of online resources – Articles, Blogs and others

Text Books:

1 Herta A Murphy, Herbert W Hildebrandt, and Jane P Thomas, Effective Business Communication, 7th Edition, McGraw Hill, Irwin, 1997.

2 Martin Hewings, Advanced Grammar in Use, 2nd Edition, Cambridge University Press, 2008.

3 Michae Swan, Practical English Usage, Oxford University Press, Oxford, 1995.

Reference Books:

1 Perelman, Leslie C, James Paradis, and Edward Barrett, The Mayfield HandBooks of Technical & Scientific Writing, Mountain View, Calif: Mayfield Pub. Co, 1998.

2 Robert Gannon, Best Science Writing: Readings and Insights, University Press, Hyderabad, 2000.

3 Shirley Taylor, Communication for Business, Longman, New Delhi, 1999.

Web link(s):

1 https://nptel.ac.in/courses/109/106/109106094/ (NPTEL Course by Prof. Aysha Iqbal, IITM)

2 https://www.youtube.com/watch?v=lQrj_7xkeNI - Technical Presentation (Part of an NPTEL Course by Prof. Prathap Haridoss, IITM)

3 https://www.youtube.com/watch?v=9SB4tfD0hxM - Technical Writing

4 https://writingcenter.fas.harvard.edu/pages/strategies-essay-writing

Course Code	:	EC354
Course Title	:	**Digital Signal Processing Laboratory**
Number of Credits	:	2
Prerequisites (Course code)	:	None
Course Type	:	ELR

Course outcomes: At the end of the course, the student will be able to:

CO1 Experiment various discrete signals.

CO2 Design and implement FIR filter and IIR filter.

CO3 Demonstrate Bayes and Min-max techniques.

CO4 Describe the various addressing modes and basic operations of TMS320C54X Processor.

CO5 Produce wave pattern and apply FIR filter implantation in the processor.

List of Experiments:

MATLAB Experiments

1. Generation of various discrete time signals.
2. Realization of correlation of two discrete signals
3. Study of linear and circular convolution.
4. Realization of sub band filter using linear convolution
5. Design and implementation of FIR filter
6. Design and implementation of IIR filter
7. Realization of STFT using FFT
8. Demonstration of Bayes technique
9. Demonstration of Min-max technique
10. Realization of FIR Wiener filter

TMS320C54X Processor Experiments

11. Study of various addressing modes
12. Sequence generation and number sorting

13 Convolution using overlap add and overlap save methods

14 Wave pattern generation

15 FIR filter implementation

Course Code	:	EC355
Course Title	:	**Microwave and Optical Communication Laboratory**
Number of Credits	:	2
Prerequisites (Course code)	:	None
Course Type	:	ELR

Course outcomes: At the end of the course, the student will be able to:

CO1 Analyze the mode characteristics of reflex klystron oscillator.

CO2 Measure power and analyze the characteristics of Gunn oscillator.

CO3 Observe radiation pattern and calculate the gain of an antenna.

CO4 Describe the properties of circulators, directional couplers and magic tee.

CO5 Discuss the characteristics of various Optical Sources, Detectors and Fiber.

List of Experiments:

1 Antenna Demonstration

2 Mode characteristics of Reflex Klystron oscillator

3 Gunn oscillator characteristics and power measurement

4 Measurement of VSWR & impedance

5 Measurement of radiation pattern and gain of an antenna

6 Properties of circulators & Directional coupler

7 Properties of the Magic Tee Junction

8 Vector Network Analyser Demonstration

9 Measurement of Numerical Aperture

10 Integrated Voice and Data Optical Communication System

11 Study of Optical Sources, Detectors and Fiber Characteristics

SEVENTH SEMESTER

Course Code	:	EC402
Course Title	:	**Wireless and Cellular Communication**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	PC

Course outcomes: At the end of the course, the student will be able to:

CO1 Discuss the evolution of cellular communication systems beyond 3G.

CO2 Design cellular link and estimate the power budget.

CO3 Choose proper multiple accessing methods depending on channel model.

CO4 Identify traffic channels for call processing.

CO5 Calculate key performance metrics of a cellular communication system.

Course Content:

An Overview of Wireless Systems - Introduction - Everything moves - Mobility versus portability - Mobile devices – Wireless communication and the layer model - First- and Second- Generation Cellular Systems - Cellular Communications from 1G to 3G - Road Map for Higher Data Rate Capability in 3G - Wireless 4G Systems - Future Wireless Networks – Standardization Activities for Cellular Systems.

Cellular System design concepts and fundamentals - Frequency Reuse – Channel Assignment - Handoff Strategies – Interference and System Capacity – Trunking and Grade of service – Improving Coverage and Capacity in cellular systems. Mobile Radio Wave propagation - I – Large scale path loss and propagation models – Reflection – Diffraction – Scattering – Practical link budget design – Outdoor propagation models – Indoor propagation models.

Mobile Radio Wave propagation – II - Small- Scale fading and multipath propagation, Rayleigh and Ricean Distributions. Multiple Access Techniques for Wireless Communications -I – FDMA – TDMA –Spread Spectrum multiple access – FHMA, CDMA – SDMA.

Multiple Access Techniques for Wireless Communications – II - Packet radio – Pure ALOHA, Slotted ALOHA, CSMA, Reservation ALOHA, PRMA - Capacity of Cellular Systems. Wireless systems and standards – I – AMPS and ETACS – IS 54 and IS 136 – GSM features – Architecture. – Radio subsystems – Traffic channels – call processing.

Wireless systems and standards – II – CDMA features – Architecture – IS 95 – Forward and reverse channels – power control - system capacity. Wireless Networking – WLAN – PAN –

Mobile network layer – Mobile Transport layer – Wireless data services, Common channel signaling. Wireless Networking – Satellite data communication - cellular data communications, third generation UMTS system features – WiMAX - RFID.

Text Books:

1 William C Y Lee, "Mobile Cellular Telecommunications, McGraw Hill.

2 Schwartz, Mobile Wireless Communications, Cambridge University Press.(Main Books)

3 Theodore S Rappaport, "Wireless Communications Principles and Practice", Prentice Hall.

Reference Books:

1 Stallings, Wireless Communications and Networks, Prentice Hall.

2 A.Goldsmith, Wireless Communications, Cambridge University Press, 2005.

3 A.F.Molisch, Wireless Communications, Wiley, 2005.

Web link(s):

1 https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-ee48/ (NPTEL Video by Prof. Koi Pillai from IIT Madras)

2 https://nptel.ac.in/courses/117/102/117102062/ (NPTEL Video by Prof. Ranjan Bose from IIT Delhi)

Course Code	:	EC403
Course Title	:	**Wireless and Cellular Communication Laboratory**
Number of Credits	:	2
Prerequisites (Course code)	:	None
Course Type	:	ELR

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the use of AT commands

CO2 Practice modulation and demodulation of DSSS signal

CO3 Analyze the functions of various parts of mobile phone

CO4 Measure the test point voltages of mobile

CO5 Demonstrate the concept behind video calling

List of Experiments:

1 Study & use of AT commands

2 Study of voice call using AT command

3 Sending message using AT command

4 Study theory of direct sequence spread spectrum modulation & demodulation

5 Generation of DSSS modulated signal

6 Demodulation of DSSS modulated signal.

7 Introduction to parts of mobile phone

8 Measurement of test point voltages of mobile

9 Observe waveforms at different test points of mobile

10 Study of switch faults

11 Video calling

ELECTIVE-I

Course Code	:	EC511
Course Title	:	**Analog IC Design**
Number of Credits	:	3
Prerequisites (Course code)	:	Networks, Electronic circuits
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe various components in CMOS process to estimate their performance in circuits.

CO2 Analyze noise in resistors and MOS transistors.

CO3 Discuss the application of opamp in data converters.

CO4 Design second order filter transfer function.

CO5 Illustrate the importance of PLL and VCO in analog IC design.

Course Content:

Review of basic amplifier stages, negative feedback and stability, frequency compensation. Single stage and two stage opamps, phase margin. Telescopic and folded cascade opamps. OTAs vs Opamps.

Opamp parameters: Slew rate, CMRR, PSRR, finite gain and bandwidth, offset voltages. Components available on an IC. Noise in resistors and MOS transistors: systematic and random mismatch, input and output referred noise, noise scaling.

Opamp applications: Precision rectifiers. Summing amplifier, Integrators and differentiators, Log and antilog amplifiers. Instrumentation amplifiers, voltage to current converters, comparator. Multivibrators. Data converters: A/D and D/A converters

Active filters: Second order filter transfer function (low pass, high pass, band pass and band reject), Butterworth, Chebyshev and Bessel filters. Switched capacitor filter. notch filter, All pass filters, self-tuned filters

PLL- basic block diagram and operation, Four quadrant multipliers. Phase detector, VCO, Applications of PLL- Frequency synthesizers. Reference voltage and current generators.

Text Books:

1 Gray, Paul R., Robert G Meyer, “Analysis and design of analog integrated circuits”, Wiley, 2001.

2 B Razavi, “Design of Analog CMOS Integrated Circuits”, (2/e), McGraw-Hill Education, 2016.

Reference Books:

1 Lee, Thomas H, “The design of CMOS radio-frequency integrated circuits”, Cambridge university press, 2003.

2 Razavi, Behzad, “RF microelectronics”, New Jersey: Prentice Hall, (2/e) 1998.

Web link(s):

1 https://nptel.ac.in/courses/117/106/117106030/ (NPTEL Video by Dr. Nagendra Krishnapura from IIT Madras)

2 https://nptel.ac.in/courses/108/106/108106105/ (NPTEL Video by S.Aniruddhan from IIT Madras)

Course Code	:	EC512
Course Title	:	**Introduction to VHDL/Verilog programming**
Number of Credits	:	3
Prerequisites (Course Code)	:	None
Course Type	:	ELE

Course Outcomes: After completion of the course, student will be able to:

CO1 Explain the concepts of HDL design flow and the procedure of simulators.

CO2 Use syntax and semantics of VHDL and develop the logic models.

CO3 Design and simulate the combinational and sequential logic circuits using different modeling styles of VHDL

CO4 Apply syntax and semantics of Verilog to develop the logic models.

CO5 Analyze data flow and behavioural styles of Verilog HDL to design combinational and sequential logic circuits.

Course Content:

Basic concepts of hardware description languages. Hierarchy, Concurrency, Logic and Delay modeling. Structural, Data-flow and Behavioural styles of hardware description. Architecture of event driven simulators.

Syntax and Semantics of VHDL. Variable and signal types, arrays and attributes. Operators, expressions and signal assignments. Entities, architecture specification and configurations. Component instantiation, Concurrent and sequential constructs, Use of Procedures and functions.

Design of Combinational and Sequential logic circuits in Structural, Data-flow and Behavioural styles of VHDL, Synthesis of logic from VHDL description.

Syntax and Semantics of Verilog. Variable types, arrays and tables. Operators, expressions and signal assignments. Modules, nets and registers, Concurrent and sequential constructs. Tasks and functions.

Design of Combinational and Sequential logic circuits in Structural, Data-flow and Behavioural styles of Verilog HDL. Synthesis of logic from Verilog HDL description.

Text Books:

1 Douglas J. Smith. " HDL Chip Design: A Practical Guide for Designing, Synthesizing &

Simulating ASICs & FPGAs Using VHDL or Verilog", Doone Publications, 1998.

2 S. Brown, Z. Vranesic. "Fund Of Digital Logic With VHDL Design, [2 ed.], McGraw-Hill, 2004

3 T.R. Padrnanabhan and B. Bala Tripura Sundari , "Design lhrough Verilog HDL", 2nd edition, WSE, 2014 IEEE Press

Reference Books:

1 M. Ferdjallah. Introduction to Digital Systems: Modeling, Synthesis, and Simulation Using VHDL, Wiley; 1st edition, 2011

2 M. Ciletti. Advanced Digital Design with the Verilog HDL. Prentice Hall; 2nd edition, 2010

3 V. Pedroni. Finite State Machines in Hardware: Theory and Design (with VHDL and SystemVerilog).The MIT Press; 2013

Web link(s):

1 https://nptel.ac.in/courses/106/105/106105165/ (NPTEL Video by Prof.Sengupta from IIT Kharagpur)

2 https://freevideolectures.com/course/3401/digital-system-design-with-plds-and-fpgas/21

(Prof. Kuruvilla Varghese from IISc Bangalore)

Course Code	:	EC513
Course Title	:	**Communication Switching Systems**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Summarize the functions of switching systems involved in telecommunication switching.

CO2 Assess the need for voice digitization and T Carrier systems.

CO3 Compare and analyze Line coding techniques and examine its error performance.

CO4 Design multistage switching structures involving time and space switching stages.

CO5 Analyze basic telecommunication traffic theory.

Course Content:

Basic elements of communication network. Switching systems. Signaling and signaling functions

Digital telephone network. TDM Principles. PCM primary multiplex group. Plesiochronous digital hierarchy. Synchronous digital hierarchy. Echo cancellers

Digital transmission and multiplexing. Synchronous versus Asynchronous transmission. Line coding . Error performance. TDM. Framing, TDM loops and rings.

Space division switching. Multiple-stage switching. Design examples. Switching matrix control. Time division switching. Multiple-stage time and space switching

Timing recovery. Jitter. Network synchronization. Digital subscriber access-ISDN . ADSL. HFC. Traffic analysis.

Text Books:

1 J.C. Bellamy, Digital Telephony, (3/e), Wiley, 2011

2 J.E. Flood, “Telecommunications Switching, Traffic and Networks” Pearson,1st edition,2012

3 E.Keiser&E.Strange, “Digital Telephony and Network Integration”, Springer, 2nd edition,1995

Reference Books:

1 Thiagarajan Viswanathan, Telecommunication Switching Systems and Networks, PHI, 2006

2 R. L.Freeman, “Fundamentals of Telecommunications” , John Wiley and Sons, 2ndedition,1999

3 M.T. Hills, Telecommunication Switching Principles, London : Allen and Unwin, 1979.

Web link(s):

1 https://nptel.ac.in/courses/117/105/117105076/ (NPTEL Course by Prof. S.L. Maskara from IIT Kharagpur)

2 https://nptel.ac.in/courses/117/104/117104104/ (NPTEL Course by Prof. Yatindra N Singh from IIT Kanpur)

Course Code	:	CS511
Course Title	:	**Advanced Computer Architecture**
Number of Credits	:	3
Prerequisites (Course code)	:	Computer Organization and Architecture
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the sequential changes in computer architecture. .

CO2 Apply parallelism both in single and multiple processors.

CO3 Describe parallel hardware constructs.

CO4 Develop skills for exploiting thread level parallelism in multiprocessor systems.

CO5 Design various levels of memories and optimize them.

Course Content:

Introduction Fundamentals of computer Architecture, Power, Fabrication, Amdahl's law, Iron's Law, Measuring and reporting performance. Pipelining - Hazards, stalls, data dependencies - Extending the MIPS Pipeline.

Instruction-Level Parallelism and Its Exploitation Instruction-Level Parallelism: Concepts and Challenges, Basic Compiler Techniques for Exposing, Reducing Branch Costs with Prediction, BTB, BHT, Bit predictor, History Predictor, RAS.

Overcoming Data Hazards with Dynamic Scheduling Dynamic Scheduling, Hardware-Based Speculation, Multiple Issue, Advanced Techniques for Instruction Delivery and Speculation, VLIW, Super Scalar Processor, Limits on ILP Hardware versus Software Speculation, Multithreading.

Multiprocessors and Thread-Level Parallelism Symmetric Shared-Memory Architectures, Distributed Shared Memory and Directory-Based Coherence, Synchronization, Models of Memory Consistency, Case studies of recent processors.

Memory Hierarchy Design Eleven Advanced Optimizations of Cache Performance, Memory Technology and Optimizations, Protection: Virtual Memory and Virtual Machines. The Design of Memory Hierarchies, Cache Performance, Cache Optimization Techniques.

Text Books:

1 David Patterson, John L. Hennessy, “Computer Architecture: A Quantitative Approach”, Sixth edition, Morgan Kaufmann, 2017.

2 Kai Hwang, Naresh Jotwani, “Advanced Computer Architecture”, Third edition, TMH, 2016.

3 John Paul Shen, Mikko H. Lipasti, “Modern Processor Design: Fundamentals of Superscalar Processors”, Waveland Press, 2005.

Reference Books:

1 Michael J. Flynn, “Computer Architecture: Pipelined and Parallel Processor Design”, First edition, Jones and Bartlett Publishers, 1995.

2 David A. Patterson, John L. Hennessy, “Computer organization and design”, Fifth edition, Morgan Kaufmann, 2013.

3 William Stallings, Computer Organization and Architecture – Designing for Performance, Eighth Edition, Pearson Education, 2010.

Web link(s):

1 https://www.sciencedirect.com/topics/computer-science/computer-architecture(etext from Science direct)

2 https://www.intel.com/content/www/us/en/programmable/support/literature/lit-tutorials.html (Tutorials from intel)

Course Code	:	EC514
Course Title	:	**Principles of Management**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the various managerial functions of an organization.

CO2 Discuss the purpose of planning in strategic management.

CO3 Analyze various organization structure for human resource management.

CO4 Evaluate employee behaviour to enrich leadership qualities and for effective communication.

CO5 Identify and distinguish budgetary and non - budgetary control techniques.

Course Content:

INTRODUCTION TO MANAGEMENT AND ORGANIZATIONS: Definition of Management – Science or Art – Manager Vs Entrepreneur- types of managers managerial roles and skills – Evolution of Management –Scientific, human relations , system and contingency approaches– Types of Business organization- Sole proprietorship, partnership, company-public and private sector enterprises- Organization culture and Environment – Current trends and issues in Management.

PLANNING: Nature and purpose of planning – Planning process – Types of planning – Objectives – Setting objectives – Policies – Planning premises – Strategic Management – Planning Tools and Techniques – Decision making steps and process.

ORGANISING: Nature and purpose – Formal and informal organization – Organization chart – Organization structure – Types – Line and staff authority – Departmentalization – delegation of authority – Centralization and decentralization – Job Design - Human Resource Management – HR Planning, Recruitment, selection, Training and Development, Performance Management , Career planning and management.

DIRECTING: Foundations of individual and group behaviour– Motivation – Motivation theories – Motivational techniques – Job satisfaction – Job enrichment – Leadership – types and theories of leadership – Communication – Process of communication – Barrier in communication – Effective communication – Communication and IT.

CONTROLLING: System and process of controlling – Budgetary and non - Budgetary control

techniques – Use of computers and IT in Management control – Productivity problems and management – Control and performance – Direct and preventive control – Reporting.

Text Books:

1 Harold Koontz and Heinz Weihrich “Essentials of Management”, Tata McGraw Hill, 2015

2 Stephen P. Robbins and Mary Coulter, “Management”, Prentice Hall (India)Pvt. Ltd., 2015

3 Robert Kreitner and Mamata Mohapatra, “ Management”, Biztantra, 2008

Reference Books:

1 Richard I Levin, David S Rubin, Statistical management, 7th Edition, Prentice Hall India, 2011.

2 Kotler, P., Keller, Kevin Lane Keller et al. Marketing Management, 3rd Edition, 2016

3 Eugene F. Brigham and Michael C. Ehrhardt, Financial Mangement: Theory and Practice, SouthWestern College Pub; 15th Edition, 2016.

Web link(s):

1 https://nptel.ac.in/courses/110/105/110105146/ (NPTEL Video by Prof.S.Srinivas from IIT Kharagpur)

2 https://nptel.ac.in/courses/122/108/122108038/ (NPTEL Video by Prof. K.B. Akhilesh from IISC Bangalore)

ELECTIVES-II

Course Code	:	EC515
Course Title	:	**Analog CMOS Design**
Number of Credits	:	3
Prerequisites (Course code)	:	Electronic Circuits
Course Type	:	ELE

Course Outcomes: After completion of the course, student will be able to:

CO1 Discuss the operation, characteristics and models of MOSFET.

CO2 Analyze the response of current source and current sink circuits.

CO3 Examine the response of voltage sources.

CO4 Explain the concept of feedback amplifiers, analyze the open loop, and closed loop configurations.

CO5 Design different types of amplifiers and analyze their characteristics.

Course Content:

Introduction MOS Transistor, I/V characteristics, Ideal MOSFET equation, Second-Order Effects, MOS Models- Device Capacitances-Small Signal Model-Spice Model.

Current source, Current source and Sinks-Current Mirror-Cascode Connection-Temperature Analysis, transient Response.

Voltage source, Voltage References, MOSFET Divider-Threshold Voltage References-Diode referenced, Bandgap Voltage References.

Feedback Amplifier MOS Amplifiers-Feedback Amplifier-Various Topologies-Negative Feedback-Open loop and closed loop analysis.

Operational Amplifier, Differential Amplifier, Source coupled pair, Operational Amplifier, Characteristics, Cascode Input Op-Amp, Operational Transconductance Amplifier

Text Books:

1 B.Razavi, “Fundamentals of Microelectronics” Wiley, 2006

2 Paul. R.Gray, Robert G. Meyer, “Analysis and Design of Analog Integrated Circuits”, Wiley, (4/e), 2001

3 R. Jacob Baker, “CMOS Circuit Design, Layout, and Simulation”, Wiley, (3/e), 2010.

Reference Books:

1 B.Razavi, “Design of Analog CMOS Integrated Circuits”, McGraw Hill Edition 2002

2 D. A. Johns and K. Martin, “Analog Integrated Circuit Design”, Wiley,1997

3 P.E.Allen, D.R. Holberg, “CMOS Analog Circuit Design”, Oxford University Press,2002

Web link(s):

1 https://nptel.ac.in/courses/117/101/117101105/ (NPTEL Video by Prof. A.N. Chandorkar from IIT Bombay)

Course Code	:	EC516
Course Title	:	**DSP structure for VLSI**
Number of Credits	:	3
Prerequisites (Course Code)	:	VLSI Systems Design
Course Type	:	ELE

Course Outcomes: After completion of the course, student will be able to:

CO1 Discuss the basic concepts of DSP and transformation techniques.

CO2 Perform Pipelining and parallel processing in FIR systems to achieve high speed and low power.

CO3 Apply Pipelining and parallel processing in IIR systems and adaptive filters.

CO4 Employ Synchronous pipelining and clocking styles in VLSI designs.

CO5 Discuss the implementation of wave-pipelined systems and asynchronous pipelining.

Course Content:

An overview of DSP concepts, Representations of DSP algorithms. Loop bound and iteration bound. Transformation Techniques: Retiming, Folding and Unfolding

Pipelining of FIR filters. Parallel processing of FIR filters. Pipelining and parallel processing for low power, Combining Pipelining and Parallel Processing. Systolic Architecture Design

Pipeline interleaving in digital filters. Pipelining and parallel processing for IIR filters. Low power IIR filter design using pipelining and parallel processing, Pipelined adaptive digital filters.

Synchronous pipelining and clocking styles, clock skew and clock distribution in bit level pipelined VLSI designs.

Wave pipelining, constraint space diagram and degree of wave pipelining, Implementation of wave- pipelined systems, Asynchronous pipelining.

Text Books:

1 K.K.Parhi, “VLSI Digital Signal Processing Systems”, John-Wiley, 2007

2 U. Meyer -Baese,” Digital Signal Processing with FPGAs”, Springer, 2004

Reference Books:

1 W.Burleson, K. Konstantinides, T.H. Meng," VLSI Signal Processing", 1996.

2 R.J. Higgins, "Digital signal processing in VLSI", 1990

3 S.Y.Kung, H.J. Whitehouse, "VLSI and modern signal processing", 1985

Web link(s):

1	https://nptel.ac.in/courses/108/105/108105157/ (NPTEL Video PROF. Mrityunjay Chakraborty from IIT Kharagpur)

Course Code	:	EC517
Course Title	:	**Mobile Communication**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the basic communication systems and its principles.

CO2 Describe the cellular concept and analyze capacity improvement techniques.

CO3 Employ mobile radio propagation mechanisms in mobile communication.

CO4 Analyze and examine the multiple access techniques and their applications.

CO5 Assess the latest wireless technologies.

Course Content:

Cellular Concept: Frequency reuse – co-channel interference - adjacent channel interference - power control for reducing interference - improving capacity in cellular systems - cell splitting - sectoring - hand
off strategies - channel assignment strategies - call blocking in cellular networks.

Mobile Radio Propagation: Reflection, Diffraction, Fading. Multipath propagation. Statistical characterization of multipath fading. Diversity techniques for mobile wireless radio systems concept of diversity branch and signal paths - combining methods - selective diversity combining - maximal ratio combining, equal gain combining.

Propagation models: Path loss prediction over hilly terrain. Practical link budget design using Path loss models. Indoor and outdoor Propagation models

Multiple access techniques: FDMA, TDMA, SDMA and CDMA. Spread spectrum. Power control. WCDMA. Capacity of multiple access schemes.

Mobile communication Standards: Overview of second generation cellular wireless systems: GSM and IS-95 standards, 3G systems: UMTS & CDMA 2000 standards and specifications OFDM and MC-CDMA. WLAN technology. Ad hoc networks. Bluetooth.

Text Books:

1 KamiloFeher, Wireless Digital Communications, PHI, 1995.

2 David Tse, Pramod Vishwanath, Fundamentls of Wireless Communications, Cambridge University Press, 2005.

3 T. S. Rapport, Wireless Communications, Principles and Practice, Prentice Hall, 2002.

Reference Books:

1 William Stallings, Wireless Communications and Networks, Prentice Hall, 2005.

2 Schwartz, Mobile Wireless Communications, Cambridge University Press, 2004.

3 Jochen Schiller, Mobile Communications, Second Edition, Pearson Education 2012.

Web link(s):

1 https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-ee48/ (NPTEL Video by Prof.David Koi Pillai from IIT Madras)

2 https://nptel.ac.in/courses/117/102/117102062/ (NPTEL Video by Prof. Ranjan Bose from IIT Delhi)

Course Code	:	EC518
Course Title	:	**High Speed Networks**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Design and develop protocols for high speed networks.

CO2 Apply queuing models for congestion control traffic management.

CO3 Describe the TCP and ATM architecture.

CO4 Compare various high speed network architectures.

CO5 Distinguish between RSVP and RTP architecture.

Course Content:

Frame Relay Networks – Asynchronous transfer mode – ATM Protocol Architecture, ATM logical Connection, ATM Cell – ATM Service Categories – AAL, High Speed LANs: Fast Ethernet, Gigabit Ethernet, Fiber Channel – Wireless LANs: applications, requirements – Architecture of 802.11

Queuing Analysis- Queuing Models – Single Server Queues – Effects of Congestion Control – Traffic Management – Congestion Control in Packet Switching Networks – Frame Relay Congestion Control

TCP Flow control – TCP Congestion Control – Retransmission – Timer Management - Exponential RTO backoff – KARN's Algorithm – Window management – Performance of TCP over ATM. Traffic and Congestion control in ATM – Requirements – Attributes –Traffic Management Frame work, Traffic Control – ABR traffic Management – ABR rate control, RM cell formats, ABR Capacity allocations – GFR traffic management

Integrated Services Architecture – Approach, Components, Services- Queuing Discipline, FQ, PS, BRFQ, GPS, WFQ – Random Early Detection, Differentiated Services

RSVP – Goals & Characteristics, Data Flow, RSVP operations, Protocol Mechanisms Multiprotocol Label Switching – Operations, Label Stacking, Protocol details – RTP – Protocol Architecture, Data Transfer Protocol, RTCP

Text Books:

1 William Stallings, “High Speed Networks and Internet”, Pearson Education, 2nd Edition, 2002

2 Warland, Pravin Varaiya, “High performance communication networks”, 2 nd Edition, Jean Harcourt Asia Pvt. Ltd., 2001

Reference Books:

1 IrvanPepelnjk, Jim Guichard, Jeff Apcar, “MPLS and VPN architecture”, Cisco Press, Volume 1 and 2, 2003

2 Abhijit S. Pandya and Ercan Sea, “ATM Technology for Broad Band Telecommunication Networks”, CRC Press, New York, 2004

Web link(s):

1 http://pages.cpsc.ucalgary.ca/~carey/CPSC641/archive/Sept2005/ (Prof. Carey Williamson from University of Calgary)

2 https://dl.acm.org/doi/10.1016/j.comcom.2004.07.013 (Dr.Sumit Ghosh from Steven Institute of Technology, USA)

Course Code	:	EC519
Course Title	:	**MEMS**
Number of Credits	:	3
Prerequisites (Course code)	:	SSD
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the intrinsic characteristics of MEMS.

CO2 Perform stress and strain analysis of materials.

CO3 Illustrate the applications of electrostatic sensors and thermal sensing techniques.

CO4 Analyze magnetic actuators and their performance.

CO5 Describe the role of MEMS in piezoresistive and piezoelectric sensors.

Course Content:

Intrinsic Characteristics of MEMS – Energy Domains and Transducers- Sensors and Actuators – Introduction to Microfabrication – Silicon based MEMS processes

New Materials – Review of Electrical and Mechanical concepts in MEMS – Semiconductor devices – Stress and strain analysis – Flexural beam bending- Torsional deflection.

Electrostatic sensors – Parallel plate capacitors – Applications – Interdigitated Finger capacitor – Comb drive devices – Micro Grippers – Micro Motors – Thermal Sensing and Actuation – Thermal expansion – Thermal couples – Thermal resistors – Thermal Bimorph – Applications

Magnetic Actuators – Micromagnetic components – Case studies of MEMS in magnetic actuators- Actuation using Shape Memory Alloys.

Piezoresistive sensors – Piezoresistive sensor materials – Stress analysis of mechanical elements – Applications to Inertia, Pressure, Tactile and Flow sensors – Piezoelectric sensors and actuators – piezoelectric effects – piezoelectric materials – Applications to Inertia , Acoustic, Tactile and Flow sensors.

Text Books:

1 Chang Liu, ‘Foundations of MEMS’, Pearson Education Inc., 2012.

2 Stephen D Senturia, ‘Microsystem Design’, Springer Publication, 2000.

3 Tai Ran Hsu, “MEMS & Micro systems Design and Manufacture” Tata McGraw Hill, New Delhi, 2002.

Reference Books:

1 Nadim Maluf,“ An Introduction to Micro Electro Mechanical System Design”, Artech House, 2000.

2 James J.Allen, Micro Electro Mechanical System Design, CRC Press Publisher, 2005.

3 Thomas M.Adams and Richard A.Layton, “Introduction MEMS, Fabrication and Application,” Springer, 2010.

Web link(s):

1 https://nptel.ac.in/courses/117/105/117105082/ (NPTEL Video by Prof. SantiramKal from IIT Kharagpur)

2 https://nptel.ac.in/courses/112/104/112104181/ (NPTEL Video by Dr. Shantanu Bhattacharya from IIT Kanpur)

ELECTIVES-III

Course Code	:	EC520
Course Title	:	**Mixed - Signal Circuit Design**
Number of Credits	:	2
Prerequisites (Course Code)	:	Linear Integrated Circuits
Course Type	:	ELE

Course Outcomes: At the end of the course, the student will be able to:

CO1 Explain the necessity of mixed signal systems and demonstrate corresponding layout techniques.

CO2 Measure the performance of Sample and Hold ciruits.

CO3 Use comparators to meet the high-speed requirements of digital circuitry.

CO4 Design circuits with minimizing jitter, switching and phase noise.

CO5 Propose a complete mixed signal system that includes efficient data conversion and RF circuits

Course Content:

Basic Building Blocks, OpAmp, Capacitors, Switches, Non-overlapping Clocks, Basic Operation and Analysis, Resistor Equivalence of a Switched Capacitor, Parasitic-Sensitive Integrator, Parasitic-Insensitive Integrators, Signal-Flow-Graph Analysis, Noise in Switched Capacitor Circuit.

Performance of Sample-and-Hold Circuits, Testing Sample and Holds, MOS Sample-and Hold Basics, Examples of CMOS S/H Circuits, Bipolar and BiCMOS Sample-and-Holds, Translinear Gain Cell, Translinear Multiplier

Comparator Specifications Input Offset and Noise, Hysteresis, Using an OpAmp for a Comparator, Input-Offset Voltage Errors, Charge-Injection Errors, Making Charge-Injection Signal Independent, Minimizing Errors Due to Charge-Injection, speed of Multi-Stage Comparators, Latched Comparators, Latch-Mode Time Constant, Latch Offset, Examples of CMOS and BiCMOS Comparators, Input-Transistor Charge Trapping, Examples of Bipolar Comparators,

Ideal D/A Converter, Ideal A/D Converter, Quantization Noise, Deterministic Approach, Stochastic Approach, Signed Codes, Performance Limitations, Resolution, Offset and Gain Error, Accuracy and Linearity

Integrating Converters, Successive-Approximation Converters, DAC-Based Successive Approximation, Charge-Redistribution A/D, Resistor-Capacitor Hybrid, Speed Estimate for Charge-Redistribution Converters, Error Correction in Successive-Approximation Converters.

Text Books:

1 David A Johns, Ken Martin, Analog IC design, Wiley 2008.

2 R Gregorian and G C Temes, Analog MOS integrated circuits for signal processing, Wiley 1986

3 Roubik Gregorian, Introduction to CMOS Op-amps and comparators, Wiley, 2008

Reference Books:

1 Behzad Razavi, "Principles of data conversion System Design", IEEE press, 1995

2 Franco Maloberti, "Data Converters", Springer, 2007

3 Rudy Van de Plassche, "CMOS Integrated Analog-to-Digital and Digital-to-Analog Converters", Kluwer Acedamic Publishers, Boston, 2003

Web link(s):

1 https://nptel.ac.in/courses/117/106/117106034/ (NPTEL Video by Dr.Shanti Pavan from IIT Madras)

2 https://nptel.ac.in/courses/111/104/111104073/ (NPTEL Video by Prof. Shalabh from IIT Kanpur)

Course Code	:	EC521
Course Title	:	**Design of ASICs**
Number of Credits	:	3
Prerequisites (Course Code)	:	None
Course Type	:	ELE

Course Outcomes: After completion of the course, student will be able to:

CO1 Demonstrate VLSI tool-flow and FPGA architecture.

CO2 Review the issues in ASIC design and the impact of technology scaling on ASIC design.

CO3 Describe the algorithms used for ASIC construction

CO4 Analyze the basics of System on Chip and its communication architectures.

CO5 Apply high performance algorithms available for ASICs

Course Content:

Types of ASICs, VLSI Design flow, Programmable ASICs - Antifuse, SRAM, EPROM, EEPROM based ASICs. Programmable ASIC logic cells and I/O cells. Programmable interconnects. Latest Version – FPGAs, CPLDs and Soft-core processors.

Trade off issues at System Level: Optimization with regard to speed, area and power, asynchronous and low power system design. ASIC physical design issues, System Partitioning, Power Dissipation, and Partitioning Methods.

ASIC floor planning, Placement and Routing.

System-On-Chip Design - SoC Design Flow, Platform-based and IP based SoC Designs, Basic Concepts of Bus-Based Communication Architectures, On-Chip Communication Architecture Standards, Low-Power SoC Design

High performance algorithms for ASICS/ SoCs as case studies – Canonic Signed Digit Arithmetic, KCM, Distributed Arithmetic, High performance digital filters for sigma-delta ADC, USB controllers.

Text Books:

1 M.J.S. Smith: Application Specific Integrated Circuits, Pearson,2003

2 H.Gerez: Algorithms for VLSI Design Automation, John Wiley,1999

3 D. A.Hodges: Analysis and Design of Digital Integrated Circuits (3/e), MGH2004

Reference Books:

1 J..M.Rabaey, A. Chandrakasan, and B.Nikolic, Digital Integrated Circuit Design Perspective (2/e), 2003

2 Hoi-Jun Yoo, KangminLeeand Jun Kyong Kim: Low-Power NoC for High-Performance SoC Design, CRC Press, 2008

3 S.Pasricha and N.Dutt: On-Chip Communication Architectures System on Chip Interconnect, Elsveir, 2008

Web link(s):

1 http://asic.co.in/ASIC-VLSI-Video-Lectures/ (Videos by Prof. S.Srinivasan from IIT Madras)

2 https://nptel.ac.in/courses/106/105/106105161/ (NPTEL Videos by Sengupta from IIT Kharagpur)

Course Code	:	CS649
Course Title	:	**Information Theory and Coding**
Number of Credits	:	3
Prerequisites (Course code)	:	Probability theory and Random Processes
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Design the channel performance using Information theory.

CO2 Apply asymptotic equipartition property theorem.

CO3 Construct efficient codes for data on imperfect communication channels.

CO4 Explain the properties of differential entropy and apply coding theorem for Gaussian channels.

CO5 Use linear block codes for error detection and correction.

Course Content:

Entropy, Relative Entropy, and Mutual Information: Entropy, Joint Entropy and Conditional Entropy, Relative Entropy and Mutual Information, Chain Rules, Data-Processing Inequality, Fano's Inequality.

Typical Sequences and Asymptotic Equipartition Property: Asymptotic Equipartition Property Theorem, Consequences of the AEP: Data Compression, High-Probability Sets and the Typical Set.

Source Coding and Data Compression: Kraft Inequality, Huffman Codes, Optimality of Huffman Codes. Channel Capacity: Symmetric Channels, Properties of Channel Capacity, Jointly Typical Sequences, Channel Coding Theorem, Fano's Inequality and the Converse to the Coding Theorem.

Differential Entropy and Gaussian Channel: Differential Entropy, AEP for Continuous Random Variables, Properties of Differential Entropy, Relative Entropy, and Mutual Information, Coding Theorem for Gaussian Channels.

Linear Binary Block Codes: Introduction, Generator and Parity-Check Matrices, Repetition and Single-Parity-Check Codes, Binary Hamming Codes, Error Detection with Linear Block Codes, Weight Distribution and Minimum Hamming Distance of a Linear Block Code, Hard-decision and Soft-decision Decoding of Linear Block Codes, Cyclic Codes, Parameters of BCH and RS Codes, Interleaved and Concatenated Codes, Convolutional Codes.

Text Books:

1 Thomas Cover and Joy Thomas, "Elements of Information Theory", Second Edition, Wiley-Interscience publication, 2006.

2 William Ryan and Shu Lin, "Channel Codes: Classical and Modern", Cambridge University Press, 2009.

Reference Books:

1 Robert Gallager, "Information Theory and Reliable Communication", 1969

2 N. Abramson, "Information and Coding", McGraw Hill, 1963

3 M. Mansurpur, "Introduction to Information Theory", McGraw Hill, 1987

Web link(s):

1 https://nptel.ac.in/courses/108/108/108108168/ (NPTEL Video by Prof. Himanshu from IISC Bangalore)

2 https://nptel.ac.in/courses/117/106/117106031/ (NPTEL Video by Dr.AndrewThangaraj from IIT Madras)

Course Code	:	CS650
Course Title	:	**Robotics**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the working principles of Robots.

CO2 Analyze the kinematics of Robots.

CO3 Discuss various sensors of Robots.

CO4 Apply suitable mechanisms to control movements of Robots.

CO5 Employ computer vision techniques for robot vision.

Course Content:

Introduction: Introduction to robotics-origin of automation, Classification of robots, Rotations and translation of vectors. Transformations and Euler angle representations, Homogenous transformations, Problems.

Robot Kinematics: Direct kinematics , Inverse kinematics. Problems. Velocity kinematics and Jacobian, Statics, singularity and Manipulability.

Sensors: Trajectory planning. Actuators, Velocity and position sensors. Range, proximity, touch sensors.

Controller: Control basics, Linear control basics, Model based control. Fore control, Impedance control. Basic mechanical design concepts.

Vision: Robot Vision, Image segmentation, Template matching, Polyhedral objects, Shape analysis. Motion planning – potential fields, projective path planning. Grasping and industrial automation.

Text Books:

1 D.K. Pratihar, “Fundamentals of Robotics”, Narosa Publishing House, New-Delhi, 2017.

2 K.S. Fu, R.C. Gonzalez, C.S.G. Lee, “Robotics”, McGraw-Hill Books Company, 1987.

3 J.J. Craig, “Introduction to Robotics”, Addison-Wesley Publishing Company, 1986.

Reference Books:

1 Mikell P Groover, Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, “Industrial Robotics, Technology programming and Applications", McGraw Hill, 2012.

2 Carl D. Crane and Joseph Duffy, "Kinematic Analysis of Robot manipulators", Cambridge University press, 2008.

3 Fu. K. S., Gonzalez. R. C. & Lee C.S.G., “Robotics control, sensing, vision and intelligence”, McGraw Hill Books co, 1987.

Web link(s):

1 http://engineering.nyu.edu/mechatronics/smart/Archive/intro_to_rob/Intro2Robotics.pdf

2 https://see.stanford.edu/Course/CS223A

Course Code	:	EC522
Course Title	:	**Automotive Electronics**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Analyze the performance indicators of transmission systems and internal combustion engines.

CO2 Explain the operations of engine lubrication, ignition and fuel supply systems.

CO3 Evaluate engine performance and emissions with reference to current environmental legislation.

CO4 Discuss the operation of gear box.

CO5 Describe the operation and performance of suspension, steering and braking systems.

Course Content:

Introduction: Layout of an automotive chassis, engine classification. Cooling Systems: Air cooling, air cleaners, Water cooling: Thermosyphon and pump circulation systems, Components of water cooling systems- Radiator, thermostat etc

Engine Lubrication: Petroils system, Splash system, Pressure lubrication and dry sump system Ignition System: Battery, Magneto and Electronic, Engine Starting drives Fuel supply system: Components in fuel supply system, types of feed pumps, air cleaners, fuel and oil filters, pressure and dry sump systems

Engine testing and Performance: Performance parameters, constant and variable speed test, heat balance test, performance characteristics. Engine Emissions: SI and CI engine emissions, emission control methods Automotive electrical and electronics: Electrical layout of an automobile, ECU, sensors, windscreen wiper, Electric horn

Transmission: Clutch- Single and multiplate clutch, semi & centrifugal clutch and fluid flywheel, Gear box: Sliding mesh, constant mesh and synchromesh gear box, selector mechanism, over drive, Propeller shaft and Differential.

Suspension System: Front and rear suspension, shock absorbers, Rear Axles mountings, Front Axle. Steering Mechanism: Manual and power steering systems, Braking System: Mechanical, Hydraulic and Air braking systems. Engine service: Engine service procedure.

Text Books:

1 William H.Crouse and Donald L. Anglin, Automotive Mechanics, Tata McGraw-Hill, 2004

2 K.M.Gupta, Automobile Engineering, Vol.1 and Vol.2, Umesh Publications, 2002

3 Kirpal Singh, Automobile Engineering, Vol.1 and Vol.2, Standard Publishers, 2003

Reference Books:

1 Joseph Heitner, Automotive Mechanics, East-West Press, 2000.

2 S. Srinivasan, "Automotive Mechanics", Tata McGraw-Hill, 2004

3 James D. Haldeman, "Automotive Electricity and Electronics", Pearson Education

Web link(s):

1 https://nptel.ac.in/courses/107/106/107106088/ (NPTEL Video by PROF. C.S.Shankar Ram, IIT Madras)

2 https://youtu.be/OWbXjvtG7Dc?list=PL5__U-kYrFIg5OEfvtnw0Cp1u8pqe1DMN (Automotive full course by Free Engineering Courses)

ELECTIVE-IV

Course Code	:	EC523
Course Title	:	**High Speed Communication Circuits and Systems**
Number of Credits	:	3
Prerequisites (Course code)	:	Electronic Circuits, Communication theory
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Analyze circuit level design issues of high speed communication systems.

CO2 Illustrate the design issues in wireless and broadband data link applications.

CO3 Explain the concept of high speed and low noise amplifiers.

CO4 Discuss the impact of noise in VCO.

CO5 Review the concept of Fractional-N Frequency Synthesizers.

Course Content:

Communication Systems Overview - Transceiver Architectures - Wave Guides and Transmission Lines - S-Parameters and Impedance Transformers - Generalized Reflection Coefficient, Smith Chart.

MOS Transistors, Passive Components, Gain-Bandwidth Issue for Broadband Amplifiers - High Frequency Broadband Amplifiers - Enhancement Techniques for Broadband Amplifiers, Narrowband Amplifiers.

Noise Modeling in Amplifiers - Noise Figure, Impact of Amplifier Nonlinearities - Low Noise Amplifiers - LNA Design Examples and Recent Techniques

Voltage Controlled Oscillators - VCO Examples and Mixers - Noise in VCO - ABC's of Power Amplifiers – Switching PAs - Modulation of Power Amplifiers - Linearization Techniques for Power Amplifiers

Overview of Phase-Locked Loops and Integer-N Frequency Synthesizers - Noise in Integer-N and Fractional-N Frequency Synthesizers - Design of Fractional-N Frequency Synthesizers and Bandwidth Extension Techniques

Text Books:

1 Lee, Thomas H. The Design of CMOS Radio-Frequency Integrated Circuits. Cambridge, UK: Cambridge University Press, 1997. ISBN: 0521835399.

2 Razavi, Behzad. RF Microelectronics. Upper Saddle River, NJ: Prentice Hall, 1998. ISBN: 0138875715.

Reference Books:

1 Kelley, Al, and Ira Pohl. A Books on C. Redwood City, CA: Benjamin Cummings, 1995 or later. ISBN: 0805316779.

2 Gonzalez, Guillermo. Microwave Transistor Amplifiers: Analysis and Design. Upper Saddle River, NJ: Prentice Hall, 1996. ISBN: 0132543354.

3 Rabaey, Jan. Digital Integrated Circuits: A Design Perspective. Upper Saddle River, NJ: Prentice Hall, 1995. ISBN: 0131786091.

Web link(s):

1 https://nptel.ac.in/courses/117/106/117106089/ (NPTEL Video by Prof.K.N.Bhatt from IIT Madras)

2 https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-776-high-speed-communication-circuits-spring-2005/ (Prof. Hae-Seung Lee from MIT)

Course Code	:	EC525
Course Title	:	**VLSI System Testing**
Number of Credits	:	3
Prerequisites (Course Code)	:	Digital Principles & System Design, VLSI System Design
Course Type	:	ELE

Course Outcomes: After completion of the course, student will be able to:

CO1 Identify the significance of testable design.

CO2 Explain the concept of yield and identify the parameters influencing the same.

CO3 Evaluate fabrication defects, errors and faults.

CO4 Apply combinational and sequential circuit test generation algorithms.

CO5 Identify techniques to improve fault coverage.

Course Content:

Basics of Testing: Fault models, Combinational logic and fault simulation, Test generation for Combinational Circuits. Current sensing based testing. Classification of sequential ATPG methods. Fault collapsing and simulation

Universal test sets: Pseudo-exhaustive and iterative logic array testing. Clocking schemes for delay fault testing. Testability classifications for path delay faults. Test generation and fault simulation for path and gate delay faults.

CMOS testing: Testing of static and dynamic circuits. Fault diagnosis: Fault models for diagnosis, Cause- effect diagnosis, Effect-cause diagnosis.

Design for testability: Scan design, Partial scan, use of scan chains, boundary scan, DFT for other test objectives, Memory Testing.

Built-in self-test: Pattern Generators, Estimation of test length, Test points to improve testability, Analysis of aliasing in linear compression, BIST methodologies, BIST for delay fault testing.

Text Books:

1 N. Jha & S.D. Gupta: Testing of Digital Systems, Cambridge, 2003

2 P. K. Lala: Digital circuit Testing and Testability, Academic Press. 1997.

3 M. Abramovici, M. A. Breuer, and A.D. Friedman: Digital System Testing and Testable Design, Computer Science Press,1990

Reference Books:

1 Michael L. Bushnell &Vishwani D. Agrawal, Essentials of Electronic Testing for Digital, memory & Mixed signal VLSI Circuits, Kluwar Academic Publishers.2000.

2 W. W. Wen: VLSI Test Principles and Architectures Design for Testability, Morgan Kaufmann Publishers. 2006

Web link(s):

1 https://nptel.ac.in/courses/117/105/117105137/ (NPTEL Video by Prof. SantanuChatopadhyay IIT Kharagpur)

2 https://nptel.ac.in/courses/106/103/106103016/ (NPTEL Video by Dr. Santosh Biswas from IIT Gawahati)

Course Code	:	EC525
Course Title	:	**Software Radio**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the design principles of software-defined radio and the architecture of transmitter.

CO2 Recommed software development methods for Radio Resource Management.

CO3 Discuss the architecture of RRM and JRRM in heterogeneous networks.

CO4 Apply modern wireless systems based on OFDM.

CO5 Explain digital hardware architectures and development methods.

Course Content:

The Need for Software Radios, What is Software Radio, Characteristics and benefits of software radio- Design Principles of Software Radio, RF Implementation issues- The Purpose of RF Front – End, Dynamic Range- The Principal Challenge of Receiver Design – RF Receiver Front- End Topologies- Enhanced Flexibility of the RF Chain with Software Radios- Importance of the Components to Overall Performance- Transmitter Architectures and Their Issues- Noise and Distortion in the RF Chain, ADC and DAC Distortion.

Profile and Radio Resource Management: Communication Profiles- Introduction, Communication Profiles, Terminal Profile, Service Profile , Network Profile, User Profile, Communication Profile Architecture, Profile Data Structure, XML Structure, Distribution of Profile Data, Access to Profile Data, Management of Communication Profiles, Communication Classmarks, Dynamic Classmarks for Reconfigurable Terminals, Compression and Coding, Meta Profile Data

Radio Resource Management in Heterogeneous Networks: Introduction, Definition of Radio Resource Management, Radio Resource Units over RRM Phases, RRM Challenges and Approaches, RRM Modelling and Investigation Approaches, Investigations of JRRM in Heterogeneous Networks, Measuring Gain in the Upper Bound Due to JRRM, Circuit-Switched System, Packet-Switched System, Functions and Principles of JRRM, General Architecture of JRRM, Detailed RRM Functions in Sub-Networks and Overall Systems

Reconfiguration of the Network Elements: Introduction, Reconfiguration of Base Stations and

Mobile Terminals, Abstract Modelling of Reconfigurable Devices, the Role of Local Intelligence in Reconfiguration, Performance Issues, Classification and Rating of Reconfigurable Hardware, Processing Elements, Connection Elements, Global Interconnect Networks, Hierarchical Interconnect Networks, Installing a New Configuration, Applying Reconfiguration Strategies, Reconfiguration Based on Comparison, Resource Recycling, Flexible Workload Management at the Physical Layer, Optimised Reconfiguration, Optimisation Parameters and Algorithms, Optimization Algorithms, Specific Reconfiguration Requirements, Reconfiguring Base Stations, Reconfiguring Mobile Terminals

Object Oriented Representation of Radios and Network Resources: Networks- Object Oriented Programming- Object Brokers- Mobile Application Environments- Joint Tactical Radio System. Case Studies in Software Radio Design: Introduction and Historical Perspective, SPEAK easyJTRS, Wireless Information Transfer System, SDR-3000 Digital Transceiver Subsystem, Spectrum Ware, CHARIOT.

Text Books:

1 Markus Dillinger, KambizMadani, "Software Defined Radio Architecture System and Functions", WILEY 2003

2 Walter Tuttle Bee, "Software Defined Radio: Enabling Technologies", 2002, WileyPublications.

3 Jeffrey H. Reed, "Software Radio: A Modern Approach to Radio Engineering", 2002, PEA Publication.

Reference Books:

1 Paul Burns, "Software Defined Radio for 3G", 2002, Artech House.

2 Markus Dillinger, KambizMadani, Nancy Alonistioti, "Software Defined Radio: Architectures, Systems and Functions", 2003, Wiley.

3 Joseph Mitola, "Software Radio Architecture: Object Oriented Approaches to wireless System Engineering", 2000, John Wiley & Sons.

Web link(s):

1 https://nptel.ac.in/courses/108/107/108107107/ (NPTEL Video by Dr. Meenakshi Rawat from IIT Roorkee)

2 https://www.classcentral.com/course/miriadax-software-defined-radio-101-with-rtl-sdr-9373

Course Code	:	EC526
Course Title	:	**Deep Learning and Neural networks**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the various strategies of neural networks to learn the pattern and analyse regularization parameters.

CO2 Discuss applicability of CNN in various real time problems.

CO3 Extend traditional deep learning methods into autoencoders and Monte Carlo methods.

CO4 Apply deep generative models to practical problems.

CO5 Evaluate model performance critically and interpret results.

Course Content:

Introduction to machine learning and neural networks: supervised learning, linear models for regression, basic neural network structure, simple examples and motivation for deep networks. Neural networks: forward propagation, cost functions, error back propagation, training by gradient descent, bias/variance and under/over fitting, regularization

Convolutional Neural Networks, Deep Unsupervised Learning, Sequence Modeling: Recurrent and Recursive Nets, Applications: Large-Scale Deep Learning, Computer Vision, Speech Recognition, Natural Language Processing, Other Applications

Deep Learning Research: linear factor models, autoencoders, structured probabilistic models for deep learning, Monte Carlo methods, confronting the partition function, Approximate Inference

Deep Generative Models: Boltzmann Machines, Deep Belief Networks, Deep Boltzmann Machines, Convolutional Boltzmann Machines, Directed Generative Nets

Lab-1: Neural networks. Exercise on neural networks. Solving problem with neural networks on Tensorflow. Lab 2: Convolutional Neural Networks (CNNs). Exercise on CNNs. Solving a problem with CNNs on Tensorflow. Lab 3: Recurrent Neural Networks (RNNs). Exercise on RNNs. solving a problem with RNNs on Tensorflow

Text Books:

1 Ian Goodfellow and YoshuaBengio and Aaron Courville. Deep Learning, An MIT Press Books Cambridge, MA, USA, 2015

2 Skansi and Sandro. Introduction to Deep Learning from Logical Calculus to Artificial Intelligence, Springer Publication, 2018.

3 Nicholas Locascio and Nikhil Buduma. Fundamentals of Deep Learning: Designing NextGeneration Machine Intelligence Algorithms, O'Reilly Media USA, 2017.

Reference Books:

1 R. O. Duda and P.E. Hart and D. G. Stork. Pattern Classification. Wiley-Interscience, 2nd Edition, 2001

2 S. Theodoridis and K. Koutroumbas. Pattern Recognition. 4th Edition, Academic Press, 2008

3 S. Russell and N. Norvig. Artificial Intelligence: A Modern Approach. Prentice Hall Series in Artificial Intelligence. 2003

Web link(s):

1 https://swayam.gov.in/nd1_noc20_cs62/preview (Swayam Course by Prof. P.K.Biswas from IIT Kharagpur)

2 https://www.coursera.org/specializations/deep-learning? (Coursera Course by Andrew Ng, Stanford University)

Course Code	:	EC527
Course Title	:	**Measurement and Instrumentation**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Measure performance metrics and estimate errors in a system.

CO2 Identify the instrument suitable for specific measurements.

CO3 Operate special measuring instruments such as Wave Analyzer and Harmonic Distortion Analyzer.

CO4 Discuss the basic principles of transducers for displacement, velocity, temperature, and pressure.

CO5 Identify data acquisition system for a specific application.

Course Content:

Measurement And Error: Sensitivity, Resolution, Accuracy and Precision, Absolute and Relative types of errors, Statistical analysis, Probability of Limiting errors, Linearity.

Instruments: Current and Resistance in instruments, Analog and Digital Multimeters, Measurement of time and Frequency – Digital Frequency Meter and applications

Impedance Measurement: Kelvin Bridge; Megger; Maxwell, Hay and Shering Bridges. Q - meter; Noise and Interference reduction techniques in Measurement Systems, Wave Analyzer, Spectrum Analyzer, FFT Analyzer, Oscilloscopes: Pulse Measurements, Delayed Time Base, Analog Storage, Sampling and Digital Storage Oscilloscopes

Transducers: Classification and selection of Transducers, Introduction to Strain, Load, Force, Displacement, Velocity, Acceleration, Pressure and Temperature Measurements; Introduction to Smart sensors and MEMS

Introduction to Data Acquisition Systems (DAS): Block Diagram, Specifications and various components of DAS, applications of DAS in various fields. General purpose Instrumentation Bus (GP-IB): Protocol, SCPI Commands and Applications to DSO and DMM

Text Books:

1 Oliver and Cage, “Electronic Measurements and Instrumentation”, McGraw Hill

2 W.D.Cooper&Felbrick, “Electronic Instrumentation & Measurement techniques”,PHI,2011

3 D.A. Bell, Reston, “Electronic Instrumentation and Measurements”, Oxford University Press India; Third edition,2013

Reference Books:

1 A.K. Sawhney , “Electrical and Electronic Measurement and Instrumentation”

2 H S Kalsi, “Electronic Instrumentation”, McGraw Hill, 3rd Edition, 2011

3 Ernest o Doebelin and Dhanesh N Manik, "Measurement Systems", McGraw-Hill, 5th Edition ,2007

Web link(s):

1 https://nptel.ac.in/courses/108/106/108106074/. (NPTEL Video by PROF. Avishek Chatterjee, IIT Kharagpur)

ELECTIVES-V

Course Code	:	EC528
Course Title	:	**FPGA Based system design**
Number of Credits	:	3
Prerequisites (Course Code)	:	None
Course Type	:	ELE

Course Outcomes: At the end of the course, the student will be able to:

CO1 Describe FPGA design flow.

CO2 Use PLDs to design Universal block.

CO3 Develop VHDL/Verilog models and synthesize targeting for different FPGAs.

CO4 Identify the building blocks of commercially available FPGA/CPLDs.

CO5 Explain the routing architectures in FPGA.

Course Content:

INTRODUCTION TO FPGAs: Evolution of programmable devices, FPGA Design flow, Applications of FPGA.

DEISGN EXAMPLES USING PLDs: Design of Universal block, Memory, Floating point multiplier, Barrel shifter.

FPGAs/CPLDs: Programming Technologies, Commercially available FPGAs, Xilinx's Vertex and Spartan, Actel's FPGA, Altera's FPGA/CPLD.

Building blocks of FPGAs/CPLDs: Configurable Logic block functionality, Routing structures, Input/output Block, Impact of logic block functionality on FPGA performance, Model for measuring delay.

Routing Architectures: Routing terminology, general strategy for routing in FPGAs, routing for row – based FPGAs, introduction to segmented channel routing, routing for symmetrical FPGAs, example of routing in a symmetrical FPGA, general approach to routing in symmetrical FPGAs, independence from FPGA routing architectures, FPGA routing structures. FPGA architectural assumptions, the logic block, the connection block, connection block topology, the switch block, switch block topology, architectural assumptions for the FPGA

Text Books:

1 John V. Old Field, Richrad C. Dorf, Field Programmable Gate Arrays, Wiley, 2008

2 Stephen D. Brown, Robert J. Francis, Jonathan Rose, Zvonko G. Vranesic, Field Programmable Gate Arrays, 2nd Edition, Springer, 1992

Reference Books:

1 Steve Kilts Advanced FPGA Design: Architecture, Implementation, and Optimization, Wiley-IEEE Press, 2007

Web link(s):

1 https://nptel.ac.in/courses/117/108/117108040/(NPTEL Videos by Prof. Kuruvilla Varghese from IISC Bangalore)

2 https://www.youtube.com/watch?v=R_8-2LtaCw8 (NPTEL Videos by Dr.S.Ramachandran from IIT Madras)

Course Code	:	EC529
Course Title	:	**Process and Fabrication Technology**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Illustrate the fabrication process of semiconductor devices in modern IC.

CO2 Explain the choice of silicon in the field of IC fabrication.

CO3 Discuss the importance of each and every step in CMOS fabrication process.

CO4 Design masks and layouts for a given process.

CO5 Develop process steps for fabricating a given device (limited to conventional structures).

Course Content:

Introduction on VLSI Design – Introduction to Bipolar Junction Transistor and MOSFET Fabrication for IC design.

Crystal Structure of Si: Defects in Crystal and Crystal growth – Epitaxy - Vapour phase Epitaxy - Molecular beam Epitaxy – Oxidation: Kinetics of Oxidation, Oxidation rate constants, Dopant Redistribution, Oxide Charges.

Diffusion: Theory of Diffusion, Infinite Source, Actual Doping Profiles, Diffusion Systems.

Ion - Implantation Process - Annealing of Damages - Masking during Implantation – Lithography - Wet Chemical Etching - Dry Etching - Plasma Etching Systems - Etching of Si,Sio2,SiN and other materials

Plasma Deposition Process - Metallization - Problems in Aluminum Metal contacts - IC BJT - From junction isolation to LOCOS - Problems in LOCOS + Trench isolation

More about BJT Fabrication – MOSFET: Metal gate vs. Self-aligned Poly-gate, Tailoring of Device Parameters - CMOS Technology - Latch - up in CMOS - BICMOS Technology

Text Books:

1 Plummer, James D. Silicon VLSI technology: fundamentals, practice and modeling. Pearson Education India, 2009.

2 S M Sze, “VLSI Technology”, McGraw-Hill, 1983.

3 Campbell, Stephen A. The science and engineering of microelectronic fabrication. Oxford university press, 2001.

Reference Books:

1 Tarui, Yasuo, ed. VLSI technology: fundamentals and applications. Vol. 12. Springer Science & Business Media, 2013.

2 Gyvez, J. Pineda, and Dhiraj Pradhan. Integrated circuit manufacturability: the art of process and design integration. Wiley-IEEE, 1999.

Web link(s):

1 https://nptel.ac.in/courses/117/106/117106093/ (NPTEL Video by Dr.Nanditha Das Gupta from IIT Madras)

2 https://nptel.ac.in/courses/108/101/108101089/ (NPTEL Video by Dr. A N Chandrokar from IIT Bombay)

Course Code	:	EC530
Course Title	:	**Telecommunication System Modelling and Simulation**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Review various simulation methodologies and estimation techniques.

CO2 Summarize the processing and generation of random signals.

CO3 Explain Monte Carlo simulation and performance estimation of wireless systems.

CO4 Apply advanced models and simulation techniques to design a communication system.

CO5 Design a communication system using efficient simulation technique.

Course Content:

SIMULATION METHODOLOGY: Introduction, Aspects of methodology, Performance Estimation, Simulation sampling frequency, Low pass equivalent simulation models for bandpass signals, Multicarrier signals, Non-linear and time-varying systems, Post processing – Basic graphical techniques and estimations.

RANDOM SIGNAL GENERATION & PROCESSING: Uniform random number generation, Mapping uniform random variables to an arbitrary pdf, Correlated and Uncorrelated Gaussian random number generation, PN sequence generation, Random signal processing, Testing of random number generators

MONTE CARLO SIMULATION: Fundamental concepts, Application to communication systems, Monte Carlo integration, Semianalytic techniques, Case study: Performance estimation of a wireless system.

ADVANCED MODELS & SIMULATION TECHNIQUES: Modeling and simulation of non-linearities: Types, Memoryless non-linearities, Nonlinearities with memory, Modeling and simulation of Time varying systems : Random process models, Tapped delay line model, Modelling and simulation of waveform channels, Discrete memoryless channel models, Markov model for discrete channels with memory

EFFICIENT SIMULATION TECHNIQUES: Tail extrapolation, pdf estimators, Importance sampling methods, Case study: Simulation of a Cellular Radio System

Text Books:

1 William.H.Tranter, K. Sam Shanmugam, Theodore. S. Rappaport, Kurt L. Kosbar, Principles of Communication Systems Simulation, Pearson Education (Singapore) Pvt. Ltd, 2004.

2 M.C. Jeruchim, P.Balaban and K. Sam Shanmugam, "Simulation of Communication Systems: Modeling, Methodology and Techniques", Plenum Press, New York, 2001.

3 Averill.M.Law and W. David Kelton, Simulation Modeling and Analysis, McGeaw Hill Inc., 2000

Reference Books:

1 Geoffrey Gorden, System Simulation, Prentice Hall of India, 2nd Edition, 1992.

2 Jerry Banks and John S. Carson, Discrete Event System Simulation, Prentice Hall of India, 1984

Web link(s):

1 http://read.pudn.com/downloads198/eBooks/931420/PrenticeHallPrincipleofCommunicationSystemSmulation.pdf

Course Code	:	EC531
Course Title	:	**Ad Hoc Wireless Networks**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Differentiate between cellular and ad hoc networks to analyse the challenges at various layers and applications.

CO2 Summarize the protocols used at MAC layer and scheduling mechanisms.

CO3 Compare and analyse types of routing protocols used for unicast and multicast routing.

CO4 Examine the network security solution and routing mechanism.

CO5 Evaluate the energy management schemes and Quality of service solution in ad hoc networks.

Course Content:

Ad-hoc Wireless Networks: Introduction, Issues in Ad-hoc Wireless Networks, Ad-hoc Wireless Internet; MAC Protocols for Ad-hoc Wireless Networks: Introduction, Issues in Designing a MAC Protocol, Design Goals of MAC Protocols, Classification of MAC protocols, Contention-Based Protocols, Contention-Based Protocols with Reservation Mechanisms, Contention-Based Protocols with Scheduling Mechanisms, MAC Protocols that Use Directional Antennas.

Routing Protocols for Ad-hoc Wireless Networks: Introduction, design issues; Classification of Routing Protocols: Table Driven Routing Protocols, On-Demand Routing Protocols, Hybrid Routing Protocols, Hierarchical Routing Protocols and Power-Aware Routing Protocols.

Multicast Routing in Ad-hoc Wireless Networks Introduction, Issues in Designing a Multicast Routing Protocol, Operation of Multicast Routing Protocols, An Architecture Reference Model for Multicast Routing Protocols, Classifications of Multicast Routing Protocols, Tree-Based Multicast Routing Protocols and Mesh-Based Multicast Routing Protocols.

Transport Layer and Security Protocols for Ad-hoc Networks: Introduction, Issues in Designing a Transport Layer Protocol; Design Goals of a Transport Layer Protocol; Classification of Transport Layer Solutions; TCP over Transport Layer Solutions; Other Transport Layer Protocols for Ad-hoc Networks; Security in Ad-hoc Wireless Networks, Issues and Challenges in Security Provisioning, Network Security Attacks, Key Management and Secure Touting Ad-

hoc Wireless Networks.

Quality of Service and Energy Management in Ad-hoc Wireless Networks: Introduction, Issues and Challenges in Providing QoS in Ad-hoc Wireless Networks, Classification of QoS Solutions, MAC Layer Solutions, Network Layer Solutions; Energy Management in Ad-hoc Wireless Networks: Introduction, Need for Energy Management in Ad-hoc Wireless Networks, Classification of Energy Management Schemes, Battery Management Schemes, Transmission Management Schemes, System Power Management Schemes.

Text Books:

1 C. S. Ram Murthy, B. S. Manoj, Ad Hoc Wireless Networks: Architectures and Protocols, Prentice Hall of India , 2nd Edition, 2005

2 RaminHekmat, Ad-hoc Networks: Fundamental Properties and Network Topologies, Springer , 1st Edition, 2006

3 Ozan K. Tonguz and Gianguigi Ferrari: Ad-hoc Wireless Networks, John Wiley, 2007.

Reference Books:

1 B. Tavli and W. Heinzelman, Mobile Ad Hoc Networks: Energy-Efficient Real-Time Data Communications, Springer , 1st Edition, 2006

2 G Anastasi, E Ancillotti, R Bernasconi, and E S Biagioni, Multi-Hop Ad Hoc Networks from Theory to Reality, Nova Science Publishers , 2008

3 C.K. Toh: Ad-hoc Mobile Wireless Networks- Protocols and Systems, Pearson Education, 2002

Web link(s):

1 https://nptel.ac.in/courses/106/105/106105160/ (NPTEL Video by Prof. Sudip Mishra from IIT Kharagpur)

2 https://ict.iitk.ac.in/courses/wireless-ad-hoc-and-sensor-networks/ (MOOC Course from IIT Kharagpur)

ELECTIVES-VI

Course Code	:	EC532
Course Title	:	**Asynchronous System Design**
Number of Credits	:	3
Prerequisites (Course Code)	:	None
Course Type	:	ELE

Course Outcomes: At the end of the course, the student will be able to:

CO1 Describe the fundamentals of Asynchronous protocols.

CO2 Analyze the performance of Asynchronous System and implement handshake circuits.

CO3 Explain various control circuits and Asynchronous system modules.

CO4 Use high level languages and tools for Asynchronous Design.

CO5 Apply commands and control flow of Balsa language for implemening Asynchronous Designs.

Course Content:

Fundamentals: Handshake protocols, Muller C-element, Muller pipeline, Circuit implementation styles, theory. Static data-flow structures: Pipelines and rings, Building blocks, examples

Performance: A quantitative view of performance, quantifying performance, Dependency graphic analysis. Handshake circuit implementation: Fork, join, and merge, Functional blocks, mutual exclusion, arbitration and metastability.

Speed-independent control circuits: Signal Transition graphs, Basic Synthesis Procedure, Implementation using state-holding gates, Summary of the synthesis Process, Design examples using Petrify. Advanced 4- phase bundled data protocols and circuits: Channels and protocols, Static type checking, More advanced latch control circuits.

High-level languages and tools: Concurrency and message passing in CSP, Tangram program examples, Tangram syntax-directed compilation, Martin‟s translation process, Using VHDL for Asynchronous Design. An Introduction to Balsa: Basic concepts, Tool set and design flow, Ancillary Balsa Tools

The Balsa language: Data types, Control flow and commands, Binary/Unary operators, Program structure. Building library Components: Parameterized descriptions, Recursive definitions. A simple DMA controller: Global Registers, Channel Registers, DMA control structure, The Balsa description.

Text Books:

1 Asynchronous Circuit Design- Chris. J. Myers, John Wiley &Sons, 2001.

2 Handshake Circuits An Asynchronous architecture for VLSI programming– Kees Van Berkel Cambridge University Press, 2004

Reference Books:

1 Principles of Asynchronous Circuit Design-Jens Sparso, Steve Furber, Kluver Academic Publishers, 2001

2 Asynchronous Sequential Machine Design and Analysis, Richard F. Tinder, 2009

3 A Designer's Guide to Asynchronous VLSI, Peter A. Beerel, Recep O. Ozdag, Marcos Ferretti, 2010

Web link(s):

1 https://freevideolectures.com/course/3166/digital-hardware-design/17 (Video Lectures by Prof.Balakrishnan from IIT Madras)

2 https://www.youtube.com/watch?v=QfIoAPio8oE (Video Lectures by Prof. Sengupta from IIT Kharagpur)

Course Code	:	EC533
Course Title	:	**Digital Signal Processors and Applications**
Number of Credits	:	3
Prerequisites (Course Code)	:	Digital Signal Processing
Course Type	:	ELE

Course Outcomes: After completion of the course, student will be able to:

CO1 Describe the architecture of fixed point DSPs.

CO2 Explain the architecture of floating point DSPs

CO3 Illustrate the features of on-chip peripheral devices.

CO4 Connect various application devices through interfacing.

CO5 Use digital signal processing algorithms for various real time applications.

Course Content:

Fixed-point DSP architectures. Basic Signal processing system. Need for DSPs. Difference between DSP and other processor architectures. TMS320C54X, ADSP21XX, DSP56XX architecture details. Addressing modes. Control and repeat operations. Interrupts. Pipeline operation. Memory Map and Buses.

Floating-point DSP architectures. TMS320C3X, DSP96XX architectures. Cache architecture. Floating-point Data formats. On-chip peripherals. Memory Map and Buses.

On-chip peripherals. Hardware details and its programming. Clock generator with PLL. Serial port. McBSP. Parallel port. DMA. EMIF. I2C. Real-time-clock (RTC). Watchdog timer.

Interfacing. Serial interface- Audio codec. Sensors - Humidity/temperature sensor, flow sensor, accelerometer, pulse sensor and finger print scanner. A/D and D/A interfaces. Parallel interface- Memory interface. RF transceiver interface – Wi-Fi and Zigbee modules.

DSP tools and applications. Implementation of Filters, DFT, QPSK Modem, Speech processing. Video processing, Video Encoding/Decoding. Biometrics. Machine Vision. High performance computing (HPC).

Text Books:

1 B.Venkataramani&M.Bhaskar, “Digital Signal Processor, Architecture, Programming and Applications”,(2/e), McGraw- Hill,2010

2 S.Srinivasan&Avtar Singh, “Digital Signal Processing, Implementations using DSP Microprocessors with Examples from TMS320C54X”, Brooks/Cole, 2004.

Reference Books:

1 S.M.Kuo&W.S.S.Gan,” Digital Signal Processors: Architectures, Implementations, and Applications”, Printice Hall, 2004

2 C.Marven&G.Ewers, “A Simple approach to digital signal processing”, Wiley Inter science, 1996

3 R.A.Haddad&T.W.Parson, “Digital Signal Processing: Theory, Applications and Hardware”, Computer Science Press NY, 1991

Web link(s):

1 http://www.nptelvideos.in/2012/11/embedded-systems.html (NPTEL Video by Dr.Santanu from IIT Delhi)

2 https://www.youtube.com/watch?v=SKuywStjBLY (NPTEL Video by Dr.Santanu from IIT Delhi)

Course Code	:	EC534
Course Title	:	**Satellite Communication**
Number of Credits	:	3
Prerequisites (Course code)	:	Digital Communication
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the orbital and functional principles of satellite communication systems.

CO2 Design, interpret, and select appropriate technologies for implementation of specified satellite communication systems.

CO3 Analyse and evaluate a satellite link and suggest enhancements to improve the link performance.

CO4 Select an appropriate modulation, multiplexing, coding and multiple access schemes for a given satellite communication link.

CO5 Propose, design and test analog and digital satellite communication systems as per given specifications.

Course Content:

Introduction: Overview of Satellite Communications, GEO, MEO and LEO satellite systems, frequency bands Orbital Mechanics: Orbit Equations, Locating the satellite w.r.t. the earth, Orbital elements, Look Angles, Orbital perturbation, Effects of earth's oblate ness ,moon and sun , Satellite eclipse, sun transit outage, Coverage angle, slant range, satellite launching.

Satellite subsystems: Attitude and Orbit Control System(AOCS), Telemetry, Tracking and Command System(TT&C), Power System, Satellite antennas, Communications subsystem, transponders.

Satellite Link Design: Basic transmission theory , System noise temperature and G/T ratio, CNR, CIR, ACI, IMI, Down link design, Up link design, System design examples

Modulation and Multiplexing: FM with multiplexed telephone signals, Analog FM SCPC, PSK, QPSK. Multiple Access Schemes: FDM/FM/FDMA, TDMA, Frame structure, frame acquisition, synchronization, TDMA in VSAT network, On-board processing, CDMA, Spread spectrum transmission and reception, DS-SS CDMA capacity,

VSAT Systems: Overview of VSAT systems, Network architectures, Access control, Multiple access selection LEO Satellite systems: Orbits, Coverage and frequency bands, off axis scanning,

delay and throughput, NGSO constellation design.

Text Books:

1 Timothy Pratt, Charles BostianJermeyAllnutt, Satellite Communications, John Wiley, Singapore, 2nd Edition, reprint 2013

2 D.Roddy,"Satellite Communication (4/e)", McGraw-Hill,2009.

3 Bruce R. Elbert, „The Satellite Communication Applications" Hand Books, Artech HouseBostan London, 1997.

Reference Books:

1 M. Richharaia, Satellite Communication Systems, BS Publishers, 2nd Edition, 2008.

2 Tri.T. Ha, Digital Satellite Communications, McGraw-Hill, 2000.

3 A.K. Maini, V.Agrawal, "Satellite Communications", Wiley IndiaPvtLtd,1999.

Web link(s):

1 https://nptel.ac.in/courses/117/105/117105131/ (NPTEL Video by Prof. Kalyan kumar from IIT Kharagpur)

2 https://nptel.ac.in/courses/106/105/106105081/ (NPTEL Video by Prof.Sujoy Ghosh from IIT Kharagpur)

Course Code	:	EC535
Course Title	:	**Secure Communication**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe security mechanism and the role of cryptography in network security.

CO2 Explain various conventional encryption models and techniques.

CO3 Analyze encryption algorithms and apply principles of cryptosystems.

CO4 Apply authentication protocol and digital signature to enforce security.

CO5 Use firewall design principles to prevent intruders, viruses and other threats.

Course Content:

Introduction: Attacks, services and mechanisms, security attacks, security services, a model for internet work security, protection through cryptography, the role of cryptography in network security.

Conventional Encryption: Conventional encryption model, classical encryption techniques, substitution techniques and transposition techniques, block cipher principles, block cipher design principles, block cipher modes of operation.

Encryption Algorithms: The data encryption standard, triple DES, International data encryption algorithm, Blowfish, RC5, characteristics of advanced symmetric block ciphers. Principles of public-key cryptosystems, the RSA algorithm, key management.

Authentication protocols & Digital Signatures : Authentication requirements, authentication functions, message authentication codes, hash functions, security of hash functions and MAC's, Digital signatures, Digital signature standard, Authentication Protocols, MD5, message digest algorithm, secure hash algorithm, HMAC.

Mail security & IP security: Pretty good privacy, S/MIME, IP security overview, IP security architecture, Authentication header, key management. Intruducers, viruses, Malware, Spyware, Spam. firewall design principles, trusted systems. Cyber crime, Cyber Law.

Text Books:

1 W. Stallings,"Cryptography and Network Security Principles and practice", 5/e, Pearson Education Asia, 2013

2 Kaufman, Perlman &Speciner, Network Security-Private Communication in a Public World, 2 nd ed., PHI, 2003.

Reference Books:

1 Thomas Koshy, "Elementary Number Theory with Applications", Elsevier India, 200

2 Stinson. D. Cryptography: Theory and Practice, 3rd edition, Chapman & Hall/CRC, 2012

Web link(s):

1 https://nptel.ac.in/courses/106/105/106105162/ (Prof. Sourav from IIT Kharagpur)

2 https://nptel.ac.in/courses/106/105/106105031/ (Dr.Debdeep from IIT Kharagpur)

ELECTIVE-VII

Course Code	:	EC536
Course Title	:	**Formal Methods for System Verification**
Number of Credits	:	3
Prerequisites (Course Code)	:	VLSI System Design
Course Type	:	ELE

Course Outcomes: At the end of the course, the student will be able to:

CO1 Estimate the effort required for verification and formulate a verification plan for complex IC designs.

CO2 Interpret the programming of system Verilog for verification.

CO3 Develop HVL based self-checking test benches both directed and random.

CO4 Apply techniques to assess the verification efficiency and identify the methods to improve it.

CO5 Select suitable formal verification methods for exhaustive verification of a design.

Course Content:

Introduction to functional verification -HDL and HVL languages -Functional verification approaches verification technologies –code coverage –functional coverage -requirements specification and the verification plan –levels of verification –directed test bench –coverage driven random based approach.

Introduction to System Verilog -data types, arrays, structures and unions –procedural blocks, tasks and functions –procedural statements –design hierarchy –interfaces.

High level modeling –data abstraction –OOPS –parallel simulation –race condition –simple and complex stimulus and response –bus functional models –response monitors –transaction level interface–self checking test benches –reference models –transfer function –score boarding –monitors -randomization in System Verilog –constrained random verification –random device configuration.

Functional coverage in System Verilog –Cover group/Cover point –coverage monitoring –Verification methodology -OVM/UVM basics –System on chip verification –system level and block level verification.

Introduction to formal verification –basics of equivalence checking and model checking –Boolean satisfiability (SAT) –assertion based verification –System Verilog assertions.

Text Books:

1 Sutherland, Stuart, Davidmann, Simon, Flake, Peter,SystemVerilog for Design:A Guide to Using SystemVerilog for Hardware Design and Modeling", Second Edition, Springer Science & Business Media, 2006

2 Chris Spear,GregTumbush,SystemVerilog for Verification: A Guide to Learning the Testbench Language Features, 3rdEdition, Springer Science & Business Media, 2012

3 Bergeron, J.,Writing Testbenches using SystemVerilog, Springer, USA, 2006.

Reference Books:

1 Rashinkar P, Paterson P, Singh L., System-on-a-chip verification: methodology and techniques, Springer Science & Business Media; 2007

2 Erik Seligman,TomSchubert,M V AchuthaKiran Kumar, Formal Verification: An Essential Toolkit for Modern VLSI Design,Morgan Kaufmann, 2015

Web link(s):

1 https://nptel.ac.in/courses/106/103/106103116/(NPTEL Video by Dr.Santhosh Biswas from IIT Guwahati)

2 https://nptel.ac.in/courses/106/103/106103182/(NPTEL Video by Prof.Arnab Sarkar from IIT Guwahati)

Course Code	:	EC537
Course Title	:	**CMOS VLSI Design**
Number of Credits	:	3
Prerequisites (Course code)	:	Digital principles and system design
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain CMOS structures and its modelling.

CO2 Infer the second order effects of MOS transistor characteristics.

CO3 Analyse and apply various CMOS static logic circuits.

CO4 Design sequential logic circuits with different design styles.

CO5 Demonstrate the functions of clocking, power reduction and distribution.

Course Content:

The MOS Transistors-Structure and Operation of MOS Transistor-MOS Transistor under static condition –MOS Device Design equations- Second order Effects-Small signal AC Characteristics. MOS Transistor Switches –Design of logic gates using CMOS Logic- Stick Diagram- Layout of basic Gates-The Complementary CMOS Inverter - DC Characteristics – NMOS Inverter.

Static CMOS Design: Complementary CMOS-Ratioed Logic-Pass Transistor Logic-Transmission Gate-Pseudo NMOS Logic-Dynamic CMOS Design –Domino CMOS Design-C^2MOS Logic-n-p-CMOS Logic.

Cascode Voltage Switch Logic (CVSL): The pFET Latch-CVSL Buffer/Inverter-AOI/OAI Logic-Dynamic CVSL-Complementary Pass Transistor Logic (CPL)-2-Input Arrays-3-Input Arrays-Dual-Pass Transistor Logic (DPL)

Static Latches and Registers –Bi-stability Principle- Multiplexer based Latches-Master -Slave Edge Triggered Register- Dynamic Latches and Registers –Dynamic Transmission Gate Edge-triggered Registers

Full Adder- Carry Look ahead adder -Carry Select Adder-Carry Save Adder-Array Multipliers – Booth Multiplier-Wallace Tree Multiplier

Text Books:

1 Sung-Mo (Steve) Kang , Yusuf Leblebici , Chul Woo Kim "CMOS Digital Integrated Circuits Analysis & Design", McGraw Hill,4th Edition 2014.

2 Jan.M.Rabaey, AnanthaChandrakasan, Borivoje Nikolic, "Digital Integrated Circuits – A Design Perspective", Pearson Education India; Second edition 2016

3 Weste and Haris ,CMOS VLSI Design 4e:" A circuits and systems perspective" Pearson Education India; 4 edition (2015)

Reference Books:

1 Kamran Eshraghian, Douglas A.Pucknell, SholehEshraghian, "Essentials of VLSI Circuits and Systems", Eastern Economy Prentice Hall of India, New Delhi, 2009.

2 JohnP.Uyemara "CMOS Logic Circuit Design" Springer International Edition,2007.

Web link(s):

1 https://nptel.ac.in/courses/108/107/108107129/ (NPTEL Video by Prof. Sudep Dasgupta from IIT Roorkee)

2 https://nptel.ac.in/courses/117/101/117101058/ (NPTEL Video by Prof. A.N. Chandorkar from IIT Bombay)

Course Code	:	EC538
Course Title	:	**Cognitive Radio**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Differentiate software defined radio and cognitive radio.

CO2 Describe the hardware and software architecture of cognitive radio.

CO3 Apply different spectrum sensing mechanisms in cognitive radio.

CO4 Design MAC and network layer protocols for cognitive radio.

CO5 Analyze the security issues in cognitive radio systems.

Course Content:

Introduction To Software-Defined Radio And Cognitive Radio: Evolution of Software Defined Radio and Cognitive radio: goals, benefits, definitions, architectures, relations with other radios, issues, enabling technologies, radio frequency spectrum and regulations.

Cognitive Radio Architecture: Cognition cycle – orient, plan, decide and act phases, Organization, SDR as a platform for Cognitive Radio – Hardware and Software Architectures, Overview of IEEE 802.22 standard for broadband wireless access in TV bands.

Spectrum Sensing And Dynamic Spectrum Access: Introduction – Primary user detection techniques – energy detection, feature detection, matched filtering, cooperative detection and other approaches, Fundamental Tradeoffs in spectrum sensing, Spectrum Sharing Models of Dynamic Spectrum Access – Unlicensed and Licensed Spectrum Sharing, Fundamental Limits of Cognitive Radio.

Mac And Network Layer Design For Cognitive Radio: MAC for cognitive radios – Polling, ALOHA, slotted ALOHA, CSMA, CSMA / CA, Network layer design – routing in cognitive radios, flow control and error control techniques.

Advanced Topics In Cognitive Radio: Overview of security issues in cognitive radios, auction based spectrum markets in cognitive radio networks, public safety and cognitive radio, cognitive radio for Internet of Things.

Text Books:

1 Joseph MitolaIII,"Software Radio Architecture: Object-Oriented Approaches to Wireless System Engineering", John Wiley & Sons Ltd. 2000.

2 Thomas W.Rondeau, Charles W. Bostain, "Artificial Intelligence in Wireless communication", ARTECH HOUSE .2009.

3 Ian F. Akyildiz, Won – Yeol Lee, Mehmet C. Vuran, Shantidev Mohanty, "Next generation / dynamic spectrum access / cognitive radio wireless networks: A Survey" Elsevier Computer Networks, May 2006.

Reference Books:

1 Huseyin Arslan (Ed.), "Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems", Springer, 2007

2 Simon Haykin, "Cognitive Radio: Brain –Empowered Wireless Communications", IEEE Journal on selected areas in communications, Feb 2005.

3 Huseyin Arslan, "Cognitive Radio, SDR and Adaptive System", Springer, 2007.

Web link(s):

1 https://nptel.ac.in/courses/108/107/108107107/ (NPTEL Video by Dr.Meenakshi Rawat from IIT Roorkee)

2 https://www.exuberantsolutions.com/cognitive-radio-simulation-training.htm (Online Course by NEX innovations)

Course Code	:	EC539
Course Title	:	**Essential Coding Theory**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe various block code techniques suitable for digital communication channel.

CO2 Employ linear codes for error detection and correction.

CO3 Examine channel encoder and decoder in software using cyclic codes.

CO4 Use BCH code to design channel encoder and decoder in hardware.

CO5 Represent Convolutional Codes with Generator Matrices and graphs.

Course Content:

Block Codes: The Digital Communication Channel, Introduction To Block Codes, Single Parity Check Codes, Product Codes, Repetition Codes, Hamming Codes, Minimum Distance Of Block Codes, Soft - Decision Decoding, Automatic Repeat Request Schemes.

Linear Codes: Definition of Linear Codes, Generator Matrices, The Standard Array, Parity - Check Matrices, Error Syndromes, Error Detection And Correction, Shortened And Extended Linear Codes.

Cyclic Codes: Definition Of Cyclic Codes, Polynomials, Generator Polynomials, Encoding Cyclic Codes, Decoding Cyclic Codes, Parity-Check Polynomials, Dual Cyclic Codes, Generator And Parity-Check Matrices Of Cyclic Codes.

Bch Codes: Linear Algebra, Galois Field, Definition and Construction of Binary BCH Codes, Error Syndromes In Finite Fields, Decoding SEC and DEC, Reed- Solomen Codes.

Convolution Codes: Convolution, Encoding Convolutional Codes, Generator Matrices For Convolutional Codes, Generator Polynomials For Convolutional Codes, Graphical Representation Of Convolutional Codes, The Viterbi Decoder.

Text Books:

1 S. Lin, D. J. Costello, Jr., Error Control Coding, Second Edition, Pearson, 2011.

2 I. Csiszàr and J. Körner, Information Theory: Coding Theorems for Discrete Memoryless Systems, Second edition, Cambridge, 2011.

3 J. Wolfowitz, Coding Theorems of Information Theory, Probability Theory and Stochastic Processes series, Springer, 1978.

Reference Books:

1 W. Ryan, S. Lin, "Channel Codes: Classical and Modern," Cambridge University Press, 2009. (Chapters 1-5)

2 Error-Control Block Codes for Communications Engineers, Artech House, 2000.

3 Robert Gallager, Information Theory and Reliable Communication,Wiley, 1st edition, 1968.

Web link(s):

1 https://nptel.ac.in/courses/117/106/117106031/ (NPTEL Video by Dr. Andrew Thangaraj from IIT Madras)

2 https://nptel.ac.in/courses/117/108/117108044/ (NPTEL Video by Prof. P. Vijay kumar from IISC Bangalore)

ELECTIVES-VIII

Course Code	:	EC540
Course Title	:	**Physical Design Automation**
Number of Credits	:	3
Prerequisites (Course Code)	:	VLSI System Design
Course Type	:	ELE

Course Outcomes: At the end of the course, the student will be able to:

CO1 Describe the concepts of VLSI and design models of IC fabrication.

CO2 Discuss the impact of physical design and the problems associated in the fabrication process.

CO3 Explain various layout optimization techniques to map them with the algorithms.

CO4 Apply basic data structures and bin based methods for effective physical design.

CO5 Employ graph algorithms for physical design.

Course Content:

VLSI design Cycle, Physical Design Cycle, Design Rules, Layout of Basic Devices, and Additional Fabrication, Design styles: full custom, standard cell, gate arrays, field programmable gate arrays, sea of gates and comparison, system packaging styles, multi-chip modules.

Design rules, layout of basic devices, fabrication process and its impact on physical design, interconnect delay, noise and cross talk, yield and fabrication cost.

Factors, Complexity Issues and NP-hard Problems, Basic Algorithms (Graph and Computational Geometry): graph search algorithms, spanning tree algorithms, shortest path algorithms, matching algorithms, min-cut and max-cut algorithms, Steiner tree algorithms.

Basic Data Structures, atomic operations for layout editors, linked list of blocks, bin based methods, neighbour pointers, corner stitching, multi-layer operations.

Graph algorithms for physical design: classes of graphs, graph problems in physical design, maximum clique and minimum coloring, algorithms for permutation and circle graphs. Partitioning algorithms: design style specific partitioning problems, group migrated algorithms, simulated annealing and evolution, and Floor planning and pin assignment, Routing and placement algorithms.

Text Books:

1 Naveed Shervani, Algorithms for VLSI Physical Design Automation, 3rd Edition, Kluwer Academic, 1999.

2 Charles J Alpert, Dinesh P Mehta, Sachin S Sapatnekar, HandBooks of Algorithms for Physical Design Automation, CRC Press, 2008

Reference Books:

1 Sadiq M. Sait, Habib Youssef, VLSI Physical Design Automation: Theory and Practice, McGraw-Hill Publishing, 1999

2 Sung Kyu Lim, Practical problems in VLSI physical design automation, 1st Edition, Springer/BSP Bookss, 2008

3 Bryan T. Preas, Michael Lorenzetti, Physical Design Automation of Vlsi Systems, Benjamin-Cummings Pub Co, 1988.

Web link(s):

1 https://nptel.ac.in/courses/106/105/106105161/ (NPTEL Video by Prof. Sengupta from IIT Kharagpur)

Course Code	:	EC541
Course Title	:	**VLSI Digital Signal Processing Systems**
Number of Credits	:	3
Prerequisites (Course Code)	:	Digital Signal Processing, VLSI System Design
Course Type	:	ELE

Course Outcomes: At the end of the course, the student will be able to:

CO1 Translate DSP algorithm into an efficient architecture and study the design of different building blocks of DSP architectures.

CO2 State the effect of round off noise computation.

CO3 Describe Bit level arithmetic Architectures and optimize the implementation of FIR filters and constant multipliers.

CO4 Design basic arithmetic units and realize their architecture for higher radices.

CO5 Explain different numerical strength reduction techniques.

Course Content:

Algorithms for fast convolution, Algorithmic strength reduction in filters and transforms: Parallel FIR Filters, DCT and inverse DCT, Parallel Architectures for Rank-OrderFilters.

Scaling and Round off Noise - State variable description of digital filters, Scaling and Round off Noise computation, Round off Noise in Pipelined IIR Filters, Round off Noise Computation using state variable description, Slow-down, Retiming and Pipelining.

Bit level arithmetic Architectures- parallel multipliers, interleaved floor-plan and bit-plane-based digital filters, Bit serial multipliers, Bit serial filter design and implementation, Canonic signed digit arithmetic, Distributed arithmetic.

Redundant arithmetic -Redundant number representations, carry free radix-2 addition and subtraction, Hybrid radix-4 addition, Radix-2 hybrid redundant multiplication architectures, data format conversion, Redundant to Nonredundant converter.

Numerical Strength Reduction - Subexpression Elimination, Multiple Constant Multiplication, Subexpression Sharing in Digital Filters, Additive and Multiplicative NumberSplitting.

Text Books:

1 Keshab Parhi, VLSI digital signal processing systems design and implementations, Wiley

1999

2 Avatar sigh, Srinivasan S, Digital signal processing implementations using DSP microprocessors with examples, Thomson 4th reprint, 2004

Reference Books:

1 Richard J. Higgins, Analog Devices Technical Reference Bookss Digital Signal Processing in VLSI, Prentice Hall, 1990

2 Magdy A. Bayoumi, VLSI, Computer Architecture and Digital Signal Processing VLSI Design Methodologies for Digital Signal Processing Architectures, 1st edition, Springer, 1994

Web link(s):

1 https://nptel.ac.in/courses/108/105/108105157/(NPTEL Video by Prof. MirutunjanChakrabarthy from IIT Kharagpur)

Course Code	:	EC542
Course Title	:	**Broadband Access Technologies**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Identify the basics of broadband technology systems and the differences between the various wired and wireless technology system.

CO2 Illustrate the aspects of last mile data transport on copper wire networks and flavors of DSL.

CO3 Summarize the versions of cable network standard and MAC protocols for HFC networks.

CO4 Distinguish between ATM based and Ethernet based passive optical networks.

CO5 Review the types of broadband wireless access technologies and their characteristics.

Course Content:

Wired access technologies using Phone line modem, ISDN modem. Comparison-Cable, DSL, fiber and wireless access technologies.

Last mile copper access, Flavors of Digital subscriber lines, DSL deployment, Common local loop impairments, discrete multitone modulation, VDSL deployment and frequency plans. Standards for XDSL and comparison.

Last mile HFC access, Cable modems. Modulation schemes, DOCSIS. Standards- comparison, physical and MAC layer protocols for HFC networks, ATM and IP-centric modem. Switched digital video

Fiber access technologies and architectures. ATM passive optical networks, Upstream and downstream transport, Frame format, Ethernet passive optical network, Gigabit passive optical networks.

Survey on emerging broadband wireless access technologies. LMDS,MMDS,WIMAX and WIFI, Satellite technologies serving as last mile solutions, Wireless LAN, Wireless personal area networking, 3G and 4G wireless systems.

Text Books:

1 N.Jayant, “Broadband last mile”-Taylor and Francisgroup,2005

2 N.Ransom& A.A. Azzam, “Broadband Access Technologies”, McGraw Hill,1999

3 M.P. Clarke, “Wireless Access Network”, Wiley,2000

Reference Books:

1 T.Starr,M.Sorbara,J.M.Cioffi and P.J.Silverman,”DSLadvances”,PrenticeHall,2002

2 S. Mervana&C.Le, “Design and Implementation of DSL-based Access Solutions”, Cisco Press, 2001.

3 W. Vermillion, “End-to-End DSL Architecture”, Cisco Press,2003

Web link(s):

1 https://nptel.ac.in/courses/117/101/117101050/ (Prof. Abhay Karandikar from IIT Bombay)

2 https://www.coursera.org/learn/network-security-communications-sscp#about (Course from Coursera by ISC Institute)

Course Code	:	EC542
Course Title	:	**Pattern Recognition**
Number of Credits	:	3
Prerequisites (Course code)	:	Probability Statistics, Machine Learning
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Determine classifiers based on Bayes theory for pattern recognition.

CO2 Use linear classifiers to identify the patterns of data.

CO3 Categorize the data using nonlinear classifier algorithms.

CO4 Employ statistical analysis to select optimal feature set.

CO5 Develop template matching module to recognize the patterns.

Course Content:

Classifiers Based on Bayes Decision Theory: Introduction , Bayes Decision Theory, Discriminant Functions and Decision Surfaces , Bayesian Classification ,Maximum Likelihood Parameter Estimation , Maximum a Posteriori Probability Estimation, Bayesian Inference , Maximum Entropy Estimation , Mixture Models , Nonparametric Estimation ,The Naive-Bayes Classifier , The Nearest Neighbor Rule, Bayesian Networks.

Linear Classifiers: Linear Discriminant Functions and Decision Hyperplanes, The Perceptron Algorithm, Least Squares Methods, Mean Square Estimation Revisited: , Logistic Discrimination, Support Vector Machines.

Non Linear Classifiers: XOR Problem, Two-Layer and Three Layer Perceptrons, Backpropagation Algorithm , Hyperparameters, Generalized Linear Classifiers, Capacity of the l-Dimensional Space in Linear Dichotomies, Polynomial Classifiers, Radial Basis Function Networks, Universal Approximators, Nonlinear SVM, Decision Trees, Boosting Approach to Combine Classifiers.

Feature Selection: Preprocessing, Statistical Hypothesis Testing, The Receiver Operating Characterisitcs (ROC) Curve, Class Separability Measures, Feature Subset selection, Optimal Feature Generation, Neural Networks and Feature Generation / Selection, The Bayesian Information Criterion.

Feature Generation: Linear Transforms, Regional Features, Features for Shape and Size

Characterization, Typical Features for Speech and Audio Classification Template Matching: Introduction, Similarity Measures Based on Optimal Path Searching Techniques, Measures Based on Correlations, Deformable Template Models.

Text Books:

1 S Theodoridis and K Koutroumbas – Pattern Recognition, 4th Edition, Academic Press, 2009.

2 C Bishop – Pattern Recognition and Machine Learning – Springer, 2006.

3 R. O. Duda and P. E. Hart, D. G. Stork, “Pattern Classification”, Wiley Interscience, Second Edition, 2007.

Reference Books:

1 R. O. Duda and P. E. Hart, D. G. Stork, “Pattern Classification”, Wiley Interscience, Second Edition, 2007.

2 J. P. Marques de Sá, “Pattern Recognition”, Springer Science & Business Media , 2001.

Web link(s):

1 https://nptel.ac.in/courses/106/106/106106046/ (NPTEL Video by Prof. Sukhendu Das from IITM)

2 https://nptel.ac.in/courses/106/108/106108057/ (NPTEL Video by Prof. M.Narasimha Murthy from IISC Bangalore)

ELECTIVES-IX

Course Code	:	EC543
Course Title	:	**Nanoelectronics**
Number of Credits	:	3
Prerequisites (Course code)	:	SSD
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Demonstrate the basic concepts of nanotechnology and related processes.

CO2 Use the fundamental concepts of nanoelectronics to design nanoscale devices.

CO3 Explain the underlying interdisciplinary aspect of nanoelectronics.

CO4 Evaluate the emerging nanoscale devices and its applications.

CO5 Choose among the various fabrication methods of nano-devices.

Course Content:

Introduction to nanoelectronics, MOS scaling theory, issues in scaling MOS transistors: short channel effects, need for non-classical MOS transistors.

Design of nanoscale transistor: CMOS Process Flow, Channel and Source/Drain Engineering, Gate oxide scaling and reliability, High-k gate dielectrics, Metal gate transistor.

Basics of Quantum Mechanics: Schrodinger equation, Density of States. Particle in a box Concepts, Degeneracy. Band Theory of Solids. Brillouin Zones.

MOS Electrical Characterization, Non Classical MOSFETs: Overview and Carrier Transport in Nano MOSFETs, Silicon On Insulator (SOI) MOSFET, Metal-Semiconductor Contacts and Metal-Source /Drain Junction MOSFETs

Nano-scale MOSFETs, FinFETs, and Vertical MOSFETs. Transport in nanoscale devices, velocity saturation, ballistic transport, injection velocity, velocity overshoot, I-V characteristics.

Text Books:

1 Karl Goser, Jan Dienstuhl and others “Nanoelectronics and Nanosystems” From Transistor to Molecular & Quantum Devices, Springer, 2004

2 G.W. Hanson, Fundamentals of Nanoelectronics, Pearson, 2009.

3 Robert Puers , LivioBaldi , Marcel Van de Voorde , Sebastiaan E. van Nooten**,** Nanoelectronics: Materials, Devices, Applications, 2 Volumes, Wiley 2017.

Reference Books:

1 Rainer Waser "Nano Electronics and Information Technology" 3rd Edition, Wiley-VCH, 2012

2 Plummer, Deal, Griffin " Silicon VLSI Technology", Pearson Education India 2009.

3 Mustafa Hussain "Advanced Nanoelectronics" by WILEY, 2018.

Web link(s):

1 https://nptel.ac.in/courses/117/108/117108047/ (NPTEL Video by Prof.K.N.Bhat from IISC Bangalore)

2 https://www.youtube.com/watch?v=p5nsWUKiG9k&list=PLtkeUZItwHK6lvGu8kFKBdhz3XaIZQDFj&index=1 (Video Lectures by Supriya Dutta from Purdue University)

Course Code	:	CS647
Course Title	:	**Digital Image Processing**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the characteristics of a digital image and analyze the image in frequency domain.

CO2 Differentiate and interpret various image enhancement techniques.

CO3 Identify noise models and employ suitable filter to remove noise.

CO4 Analyze and use appropriate image compression techniques.

CO5 Apply suitable techniques to segment different regions of an image.

Course Content:

Introduction: Digital Image Processing – Characteristics of Digital Image - Basic relationship between pixels - Image sampling and quantization - Color models. Basic Geometric Transformations - Fourier Transform – Cosine, Sine and Hartley Transform – Hadamard, Haar, Slant Transform – Discrete Fourier Transform.

Image Enhancement Techniques: Spatial Domain Methods - Basic Grey Level Transformation – Histogram Processing – Image subtraction – Image averaging – Spatial filtering - Smoothing, Sharpening filters – Laplacian filters – Frequency domain filters - Smoothing – Sharpening filters – Homomorphic filtering.

Image Restoration: Model of Image Degradation/restoration process – Noise models – Spatial and Frequency Filters- Inverse filtering & Wiener Filtering - Least mean square filtering – Constrained least mean square filtering.

Image Compression Fundamentals: Image Compression Models - Lossless compression: Variable length coding – LZW coding – Bit plane coding- predictive coding-DPCM. Lossy Compression: Lossy Predictive Coding - Transform coding – Wavelet coding.

Image Segmentation & Analysis: Image Segmentation techniques - Edge detection – Thresholding – Region - Boundary Extraction & Representation – Region, Moment representation, chain codes- Polygonal approximation, Texture, Pattern Recognition.

Applications - Finger print/iris recognition - Remote sensing - Automatic character recognition - Medical image processing.

Text Books:

1 Rafael C Gonzalez, Richard E Woods,"Digital Image Processing", Pearson Education, 4th edition, 2010.

2 A.K. Jain, "Fundamentals of Digital Image Processing", PHI, New Delhi, 1995.

3 William K Pratt, "Digital Image Processing", 4rd Edition, John Willey, 2007.

Reference Books:

1 SE Umbaugh, "Digital Image Processing and Analysis: Application with MATLAB and CVIP tools", 3rd Edition , Taylor & Francis, CRC Press, 2018.

2 Frank Y. Shih, "Image processing and Pattern Recognition", Wiley – IEEE press, 2010.

Web link(s):

1 https://nptel.ac.in/courses/117/105/117105135/(NPTEL Course by Prof. P.K. Biswas from IIT Kharagpur)

2 https://nptel.ac.in/courses/117/104/117104069/(NPTEL Course by Prof. Sumana Gupta from IIT Kanpur)

Course Code	:	EC544
Course Title	:	**Radar System and Analysis**
Number of Credits	:	3
Prerequisites	:	None
Course Type	:	ELE

Course Outcomes: At the end of the course, the student will be able to:

CO1 Describe the basic operation of pulse and CW radar systems.

CO2 Evaluate the radar performance based on pulse width, peak power and beam width.

CO3 Choose suitable tracking radar for a given problem.

CO4 Select appropriate criterion for detecting a target.

CO5 Explain the working of phased array radars and navigational aids.

Course Content:

Radar and Radar Equation: Introduction, Radar block diagram and operation, frequencies, applications, types of displays, derivation of radar equation, minimum detectable signal, probability of false alarm and threshold detection, radar cross-section, system losses.

CW Radar – Doppler Effect, CW Radar, applications, FM – CW radar, altimeter, Multiple Frequency Radar. Pulse Radar – MTI, Delay Line Canceller, Multiple Frequencies, Range-gated Doppler Filters, Non-coherent MTI, Pulse Doppler Radar.

Tracking Radar- Sequential lobing, conical scanning, mono pulse, phase comparison mono pulse, tracking in range, comparison of trackers.

Detection – Introduction, Matched Filter, Detection Criteria, Detector characteristics.

Phased Arrays – Basic concepts, feeds, phase shifters, frequency scan arrays, multiple beams, applications, advantages and limitations. Navigational Aids: Direction Finder, VOR, ILS and Loran.

Text Books:

1. M.I. Skolnik, Introduction Radar Systems, Second Edition, Mc Graw Hill Books Co., 1981
2. F.E. Terman, Radio Engineering, Mc Graw Hill Books Co. (for Chapter 7 only), Fourth

Edition 1955

3. Simon Kingsley & Shaun Quegan, Understanding RADAR Systems, McGraw Hill Books Co., 1993.

Reference Books:

1 Bassem R. Mahafza Radar Systems Analysis and Design Using MATLAB [1 ed.], Chapman & Hall/CRC, 2000

2 Hamish D. Meikle,"Modern Radar Systems" [1st ed.], Artech House, 2001

Web link(s):

1 https://nptel.ac.in/courses/108/105/108105154/ (NPTEL Video by Prof.AmitabhaBattacharya from IIT Kharagpur)

Course Code	:	CS541
Course Title	:	**Virtual Reality**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	ELE

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the basic concept and framework of virtual reality.

CO2 State the computer-human interaction.

CO3 Apply computer graphics techniques to virtual reality programs.

CO4 Use tools and frameworks to create virtual reality applications.

CO5 Apply virtual reality technology in film and digital entertainment industry.

Course Content:

Introduction: Fundamental Concept and Components of Virtual Reality, Primary Features and Present Development on Virtual Reality.

Interface: Multiple Models of Input and Output Interface in Virtual Reality: Input -- Tracker, Sensor, Digital Glove, Movement Capture, Video-based Input, 3D Menus & 3DScanner etc. Output -- Visual /Auditory / Haptic Devices.

Visual Computation: Fundamentals of Computer Graphics, Software and Hardware Technology on Stereoscopic Display, Advanced Techniques: Management of Large Scale Environments & Real Time Rendering.

Techniques: Interactive Techniques in Virtual Reality: Body Track, Hand Gesture, 3D Manus, Object Grasp, Development Tools and Frameworks in Virtual Reality: Frameworks of Software Development Tools in VR. X3D Standard, Vega, MultiGen, Virtools etc.

Applications: Virtual Reality Technology in Film & TV Production. Virtual Reality Technology in Physical Exercises and Games, Demonstration of Digital Entertainment by Virtual Reality.

Text Books:

1 Burdea, G. C. and P. Coffet, “Virtual Reality Technology”, Second Edition, Wiley-IEEE Press, 2006.

Reference Books:

1 Alan B Craig, William R Sherman and Jeffrey D Will, “Developing Virtual Reality Applications: Foundations of Effective Design”, Morgan Kaufmann, 2009.

2 William R Sherman and Alan B Craig, “Understanding Virtual Reality: Interface, Application and Design (The Morgan Kaufmann Series in Computer Graphics)”. Morgan Kaufmann Publishers, San Francisco, CA, 2002.

Web link(s):

1 https://stanford.edu/class/ee267/ (Gordon Wetzstein from Standford University)

2 https://nptel.ac.in/courses/106/106/106106138/ (NPTEL Video by Prof. Steven Lavalle from IITM)

GLOBAL ELECTIVES-I

Course Code	:	CS646
Course Title	:	**Internet of Things**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	GE

Course outcomes: At the end of the course, the student will be able to:

CO1 Discuss the architecture of IoT network.

CO2 Analyze various protocols of IoT for efficient network communication.

CO3 Design and develop an IoT system using Rasperry Pi/Arduino.

CO4 Evaluate the security constraints in IoT applications.

CO5 Demonstrate applications of IoT in real time scenario.

Course Content:

Introduction: What Is IoT?: Genesis of IoT, IoT and Digitization, IoT Impact, Convergence of IT and OT, IoT Challenges, IoT Network Architecture and Design: Drivers Behind New Network Architectures, Comparing IoT Architectures, A Simplified IoT Architecture, Core IoT Functional Stack, IoT Data Management and Compute Stack, Smart Objects, Connecting Smart Objects.

IoT Protocols: IoT Access Technologies: IEEE 802.15.4, IEEE 802.15.4g, IEEE 802.15.4e, IEEE 1901.2a, IEEE 802.11ah, LoRaWAN. Network Layer: Need for Optimization, Optimizing IP for IoT, From 6LoWPAN to 6Lo, Profiles and Compliances, Transport Layer, Application Transport Methods: Supervisory Control and Data Acquisition (SCADA), Application Layer: CoAP, Message Queuing Telemetry Transport (MQTT)

Design and Develop: Design Methodology - Embedded computing logic - Microcontroller, System on Chips - IoT system building blocks - Arduino Basics, Internet Connectivity, Communication Protocols, Complex Flows: Node-RED, Realtime Clients, Remote Control, Installing Raspbian on the Raspberry Pi, Writing Python Programs Using Raspberry Pi, Using the GPIO to Connect to the Outside World, Subscribing to Web Services, Controlling a Servo with Python, Tinkercad, Cayenne cloud / ThingSpeak.

IoT Security: History of OT Security, Common Challenges in OT Security, Insecure Operational Protocols, Modbus, DNP3, ICCP, OPC, IEC Protocols, Purdue Model for Control Hierarchy, OT Network Characteristics Impacting Security, Formal Risk Analysis Structures: OCTAVE and FAIR, Phased Application of Security in an Operational Environment. Multiple security levels, Security and Privacy Issues in IoT, Privacy

preserving algorithms in IoT, Complexity Analysis of the cryptographic algorithms in IoT.

Applications: Manufacturing: An Architecture for the Connected Factory - Edge Computing in the Connected Factory, Utilities- Smart grid, Electrical Vehicle Charging, Smart and Connected Cities: An IoT Strategy for Smarter Cities - Smart City Use-Case Examples, Transportation: Transportation Challenges - Extending Bus IoT Architecture to Railways, Mining: An IoT Strategy for Mining, An Architecture for IoT in Mining, Public Safety: An IoT Blueprint for Public Safety - IoT Public Safety Information Processing, Case Studies: IoT in Disaster Management System, Agriculture, Healthcare, Activity Monitoring.

Text Books:

1 David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things", 1st edition, Cisco Press, 2017

2 Adeel Javed, "Building Arduino Projects for the Internet of Things: Experiments with Real-World Applications", 1st Edition, Apress, 2016.

3 Colin Dow,"Internet of Things Programming Projects: Build modern IoT solutions with the Raspberry Pi 3 and Python", 1st edition, Packt Publishing, 2018.

Reference Books:

1 Arshdeep Bahga, Vijay Madisetti, "Internet of Things – A hands-on approach", Universities Press, 2015.

2 Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle,"From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence",1st Edition, Academic Press, 2014.

3 Tom Igoe, "Making Things Talk, Second Edition, O'Reilly Media, Inc, 2011.

Web link(s):

1 IoT: https://onlinecourses.nptel.ac.in/noc20_cs66/preview

2 Arduino: https://www.arduino.cc/, Raspberry Pi: https://www.raspberrypi.org/

3 Arduino Tutorials: https://www.programmingelectronics.com/arduino-tutorials-all/

Course Code	:	EC645
Course Title	:	**Machine Learning**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	GE

Course outcomes: At the end of the course, the student will be able to:

CO1 Explain the basic concepts of Machine learning.

CO2 Apply the linear models for regression in Machine learning.

CO3 Use clustering techniques and graphical models of Machine learning algorithms.

CO4 Review the various reinforcement models of Machine learning.

CO5 Employ machine learning algorithms to real data and evaluate their performance.

Course Content:

Introduction – Well defined learning problems - Designing Learning System - Perspectives & Issues in Machine Learning - Types of Machine learning: supervised learning, unsupervised learning and reinforcement learning - The machine learning process.

Regression–Maximum Likelihood Estimation (MLS)–least squares– regularized least squares– Bayesian Linear Regression– Linear models for classification– Discriminant functions– Probabilistic generative models–Probabilistic discriminative models–Bayesian logistic regression–maximum a posterior (MAP) estimation.

Clustering and Dimensionality Reduction - Mixture Densities – K-means Clustering – Expectation- Maximization algorithm – Hierarchal Clustering – Choosing the number of clusters – Spectral Clustering – Dimensionality Reduction – Principal Component Analysis (PCA) – Linear Discriminant Analysis (LDA)

Graphical and Markov models– Canonical Cases for Conditional Independence – Example Graphical Models - Markov random fields – Hidden Markov Models – Representation – learning – Decoding - Inference in graphical models –Monte Carlo models.

Reinforcement Learning – Elements of reinforcement learning – Model based– temporal difference learning – Generalization – Partially observable states – The learning task – Q-learning..

Text Books:

1 Tom Mitchell, Machine Learning, McGraw-Hill, 1997

2 Stephen Marsland, ―Machine Learning – An Algorithmic Perspective‖, Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.

3 E. Alpaydin, Introduction to Machine Learning, 2nd edition, Prentice-Hall of India, 2010

Reference Books:

1 R.O. Duda, P.E. Hart and D.G. Stork. Pattern Classification. Wiley-Inderscience, 2nd Edition, 2000.

2 T. Hastie, R. Tibshirani and J. Friedman, The Elements of Statistical Learning: Springer, 2011

3 Shai Shalev-Shwartz, Shai Ben-David, Understanding Machine Learning from Theory to Algorithms, Cambridge University Press, 2014

Web link(s):

1 https://towardsdatascience.com/machine-learning/home

2 https://dzone.com/refcardz/machine-learning-predictive

Course Code	:	EC646
Course Title	:	**Web Programming**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	GE

Course outcomes: At the end of the course, the student will be able to:

CO1 Design a basic website using HTML and Cascading Style Sheets.

CO2 Construct dynamic and interactive web sites using appropriate technologies.

CO3 Write server side programs for real time applications.

CO4 Develop real client applications with PHP.

CO5 Create database and utilize them in web applications.

Course Content:

Webpage Designing: HTML- List, Tables, Images, Forms, Frames, Cascading Style sheets.* XML- Document type definition, XML Schemas,* Document Object model

Scripting: Java Script -Control statements, Functions, Arrays, Objects, Events, Dynamic HTML with Java Script, Ajax.

Web Application: Web servers –IIS (XAMPP, LAMPP)and Tomcat Servers. Java Web Technologies- Servlets, JavaServer Pages, Java Server Faces, Web Technologies in Netbeans, Building a Web Application in Netbeans, JSF Components, Session Tracking, Cookies.

PHP Programming: PHP- Basics, String Processing and Regular Expressions, Form Processing and Business Logic, Using Cookies, Dynamic Content, Operator Precedence Chart

JDBC: Database Connectivity with MySQL - Servlets, JSP, PHP. Case Studies- Student information system, Health Management System.

Text Books:

1 Paul J. Deitel, Harvey M. Deitel, Abbey Deitel, "Internet & World Wide Web How to Program", Deitel series, 5th edition, 2018

2 Jason Gilmore, “Beginning PHP and MySQL From Novice to Professional”, 4th Edition, Apress Publications, 2010

3 Ron Schmelzer, Travis Vandersypen, Jason Bloomberg, Madhu Siddalingaiah, Sam hunting, MichealD.Qualls, David Houlding, Chad Darby, Diane Kennedy, “XML and Web Services”, Sams, 2002.

Reference Books:

1 Robert W. Sebesta, “Programming with World Wide Web”, Addison Wesley, 7th edition, 2013

2 Jeffrey C and Jackson, — “Web Technologies - A Computer Science Perspective”, Pearson Education, 2011.

3 David William Barron, “The World of Scripting Languages”, Wiley Publications, 2000

Web link(s):

1 www.w3schools.com

2 https://web.stanford.edu/class/cs142/lectures.html

GLOBAL ELECTIVES-II

Course Code	:	HM611
Course Title	:	**Intellectual Property Rights**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	GE

Course outcomes: At the end of the course, the student will be able to:

CO1 State the importance of intellectual property rights.

CO2 Describe the various aspects of patents to understand the process of patent filing.

CO3 Explain the scope of trademark and related features.

CO4 Analyze the importance of copyrights in reproduction and distribution.

CO5 Evaluate the significance of trade secret and its legal implications.

Course Content:

Introduction, Types and Importance of Intellectual Property Rights (IPR) – The Evolutionary Past - The IPR Tool - Legal and Ethical Tasks in Intellectual Property Law– New developments in IPR, Technological research, Innovations and Inventions, International Organizations, Agencies and treaties, IPR in India.

Patents: Need, subject matter, Classification ofpatents in India, Rights of a patent, Patent Searching, Patent Drafting, filing of a patent, applying and granting of patents, types of patent application, infringement and defences, limitations of patent rights, the international patent system.

Introduction, to Trade mark: Types and Importance– Purpose, Duration and function of Trade mark, Registration and acquisition Process, – Trade mark maintenance - Transfer of Rights - Infringement – Dilution, Ownership of Trade mark – Likelihood of confusion - Trademarks claims and Litigations – International Trade mark Law.

Introduction and Importance of Copyrights: Fundamentals of Copyrights Law, Copyright Ownership and issues, Originality of Material, Transfer and duration, Rights to Reproduction and Distribution, Rights to Perform the Work Publicly, Copyright Formalities and Registration, Copyright disputes and International Copyright law.

Introduction to Trade Secret: Determination of trade Secrets Status, Maintaining Trade

Secret – Physical Security – Employee Limitation and confidentiality agreement - Trade Secret Law - Unfair Competition – Trade Secret Litigation – Breach of Contract, Geographic indication, managing intellectual property in a knowledge-based society. IPR and technology transfer, famous IPR case studies.

Text Books:

1 DebiragE.Bouchoux: "Intellectual Property". Cengage learning, New Delhi.

2 M.Ashok Kumar and Mohd.Iqbal Ali: "Intellectual Property Right" Serials Pub. Cyber Law. Texts & Cases, South-Western's Special Topics Collections.

3 Prabhuddha Ganguli: 'Intellectual Property Rights" Tata Mc-Graw –Hill, New Delhi.

Reference Books:

1 Jayashree, Watal, "Intellectual Property Rights In The WTO And Developing Contries", Oxford University Press.

2 T. Ramappa, "Intellectual Property Rights under WTO" S. Chand.

3 Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 4e Revised, ASPEN publishers, 2007.

Web link(s):

1 https://nptel.ac.in/courses/109/106/109106137/

2 https://nptel.ac.in/courses/110/105/110105139/

Course Code	:	HM612
Course Title	:	**Economics of Information Technology**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	GE

Course outcomes: At the end of the course, the student will be able to:

CO1 Describe the economic characteristics of IT industry.

CO2 Employ various pricing strategies for products.

CO3 Perform switching cost analysis.

CO4 Analyze the effect of network in IT industry.

CO5 Create awareness about copyrights and patents.

Course Content:

Introduction: Overview of Information Technology Economics, Economic characteristics of the IT industry, Technology and market structure, Information Technology as Intellectual property, The Internet Boom, Combinatorial Innovation, Demand (Schumpeter), Supply side, Development of complements, Internet revolution, financial speculations, Moore's Law, the new economy of IT.

Pricing strategies: Personalization and Differentiation of product and prices, versioning, degrees of price discrimination, conditioning on purchase history, search good, bundling, dispersion of willingness to pay and barriers to entry.

Switching cost: Lock-in, Simple analytics of Lock-in, Klemperer (1995) model, Competition to acquire customers, Analytics to acquire customers, Switching cost and price discrimination, Supply and Demand side Economies of Scale, Competition and Welfare, Competing for Monopoly, Duopoly, the currency of competition and rules of games.

Network effect, Exploitation of network effect, Standards: Standard wars, Negotiations, Leaders, Cost advantages of Standardization, Windows versus Linux Case, the Napster case Economics of piracy, Reproduction and Degradation cost, System effects, Computer mediated transactions.

Intellectual Property Rights: Intellectual Property Right in Information Technology sector, Competition in IPR for Information Technology, Copyrights, Patents (offensive and defensive

portfolio) and Trade secrets, secrecy to protect software programs, need for reform in patent. system in IT.

Text Books:

1 Hal R. Varian, "Economics of Information Technology", University of California, Berkeley, 2004.

2 Hal R. Varian, Joseph Farrell, Carl Shapiro, "The Economics of Information Technology: An Introduction", Cambridge University press, 2004.

Reference Books:

1 Shapiro and Varian , "Information rules", Harvard Business School Press,1999.

Course Code	:	HM613
Course Title	:	**Health Economics and Health Technology Assessment**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	GE

Course outcomes: At the end of the course, the student will be able to:

CO1 Discuss the need for Health Economics.

CO2 Describe the infrastructure of Health Economics system.

CO3 Explain different ways of delivering health care schemes

CO4 Analyze cost-utility for health technology assessment and its contribution in policy making.

CO5 Summarize systematic reviews and construct guidelines for health economics research.

Course Content:

Introduction: Basic introduction toHealth Economics, Consumer Behaviour, Problems in health care Market, Demand and Supply, Measuring Elasticity, Determinants of demand, Supply and costs of health service, Marginal analysis and opportunity cost, Grossman's Demand for Healthcare.

Production, Cost and Market for Health care: Behaviour models, Managed Care, Health Care Professionals, Hospitals Services, Health Insurance, Demand for Insurance: Expected Utility, Information, Complexity, Impact Evaluation, and Decision-Making, Basic market model in different aspects of health care, Market Imperfections, Cases of market failure, Akerlof Model, Asymmetric information, Adverse Selection: Graphical Analysis, Moral Hazard, Externalities, Health as Public and Private Goods.

Delivery of Health Care: The Labor Market for Physicians, The Hospital Industry, Why are Costs so High? Roles and limitations of market and Government in finance and organization of health care, Healthcare Financing, Equity and efficiency, Social Determinants of Health, Population, Health and Development, Population Aging, International Health Care Systems, Alternative Designs, Health Planning and Policies (Especially India).

Health Technology Assessment and Health System Policy-Making, Fundamentals of HTA, Economic, Social and Epidemiological Contexts, Choosing HTA topic, Primary data methods, Assessing quality, validity, strength and limitations, Methods of economic evaluation, collecting cost data, key attributes of Cost analysis, Measurement of costs and benefits, cost-effectiveness, cost-utility analysis, Budget impact, Statistics in health economic evaluation including Quality of life, QALY's and DALY's.

Evidence-Based Healthcare: tools and databases, international resources, Issues of Data, integrative methods: Systematic Reviews and Critical Appraisal (Simple), guidelines for reporting primary and secondary research, modelling, Information and Knowledge in HTA, Technology Growth and Innovation, Pharmaceutical Markets and Innovation in HTA.

Text Books:

1 Folland, Goodmand, and Stano (FSG), "The Economics of Health and Health Care", 5th Edition, Pearson Prentice Hall Press, 2012.

2 Stephen Morris, Nancy Devlin, David Parkin, " Economic Analysis in Health Care", John Wiley & Sons, 2007.

3 Jay Bhattacharya, Timothy Hyde, Peter Tu., "Health Economics", Palgrave MacMillan, 2013.

Reference Books:

1 James W. Henderson, "Health Economics and Policy", Thomson-South-Western, (Indian edition by Akash Press, New Delhi) 2010.

2 Peter Bo Poulsen, "Health Technology Assessment and Diffiusion of Health Technology" Odense University Press, Paperback Edition, 1999.

3 Michael F. Drummond , "Methods for the Economic Evaluation of Health Care Programmes" (Paperback), 1987

Web link(s):

1 https://www.nlm.nih.gov/nichsr/hta101/HTA_101_FINAL_7-23-14.pdf

2 https://swayam.gov.in/nd1_noc19_mg50/preview

Course Code	:	HM614
Course Title	:	**Managerial Economics**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	GE

Course outcomes: At the end of the course, the student will be able to:

CO1 Discuss the importance of economics in engineering.

CO2 Analyze demand and supply to understand consumer behavior.

CO3 Estimate production related variables for cost analysis and maximize profit.

CO4 Evaluate market structure for suitable price determination.

CO5 Discuss the impact of inflation and business cycles on Indian economy.

Course Content

Basic economic concept – Importance of economic in engineering; Introduction to Managerial Economics; Applications of Economics in Managerial Decisions; Basic Techniques in Managerial Economics: Opportunity Cost; Role of the Managerial Economists.

The Theory of Consumer Behavior: Demand Analysis and Supply Analysis; Law of Demand and supply; Shifts in demand and supply, Determinants of Demand and supply; Elasticity of Demand and supply &Types, and Measurement, Determinants of Elasticity, uses and importance, Demand Forecasting; Methods or Techniques, Criteria for Good Demand Forecasting, The Meaning of Utility and Marginal Utility Analysis; Law of Diminishing Marginal Utility; Indifference Curve Analysis; Consumer's Equilibrium.

Production and Costs Analysis: Theory of production; Law of Variable Proportions; General Applicability of Law of Diminishing Returns; Types of Costs, Determinants of Costs; Cost-Output Relationship, Cost Forecasting; law of returns; Economies of scale: Internal and external; Profit Analysis: Theories of Profit; Depreciation; Profit Maximization and Planning; Cost-Volume-Profit (CVP) Relations; Break Even Analysis

Market Structure and Price Determination: Various Forms of Market Structures; Price

and Output Determination by the firm and Industry under various market structures e.g., Perfect Competition, Monopoly; Monopolistic Competition; Oligopoly; duopoly sorbent features of price determination and various market conditions. Business Decision Making under Risk and Uncertainty: Insurable and Non-Insurable Risk.

Nature and characteristics of Indian economy, concepts of LPG, elementary concepts of National Income, Inflation and Business Cycles ,Concept of N.I. and Measurement., Meaning of Inflation, Types and causes , Phases of business cycle Investment decisions for boosting economy(National income and per capital income).

Text Books:

1 Dominick Salvatore, "Managerial Economics: Principles and Worldwide Applications", Oxford University Press, 2008.

2 Keat, Young and Banerjee, " Managerial Economics", Pearson Education, New Delhi, 2007.

3 Mote, Samuel Paul and G.S. Gupta, "Managerial Economics: Concepts and Cases", Tata Mgraw Hill, 1977.

Reference Books:

1 Ghosh Geetika. Managerial Economics, Tata Mgraw Hill

2 Varshney and Maheswari, Managerial Economics.

3 Dwivedi DN, "Principles of Microeconomics", Pearson Education.

Web link(s):

1 https://nptel.ac.in/courses/110/101/110101005/

2 https://nptel.ac.in/courses/110/105/110105075/

Course Code	:	HM615
Course Title	:	**Management Information Systems**
Number of Credits	:	3
Prerequisites (Course code)	:	None
Course Type	:	GE

Course outcomes: At the end of the course, the student will be able to:

CO1 Discuss key terminologies and concepts of major areas of management.

CO2 Design, develop and apply information technology solutions for business problems.

CO3 Analyze computing systems and telecommunication networks suitable for business information systems.

CO4 Identify ethical issues that occur in business and evaluate alternative courses of actions.

CO5 Combine analytical thinking and creativity to solve management related problems.

Course Content:

Introduction: Information Systems in Global Business Today, Global E-Business and collaboration, Information Systems, Organization and Strategy, Ethical and social issues in Information Systems.

Emerging Technologies and Information Management: IT infrastructure and Emerging Technologies, Foundations of Business Intelligence: Databases and Information Management.

Technologies in Enterprises: Telecommunications, the internet and Wireless Technology, Securing Information Systems, Achieving Operational Excellence and Customer Intimacy: Enterprise Applications.

Introduction to D-commerce: E – Commerce: Digital Markets, Digital Goods, Managing Knowledge, Enhancing Decision Making.

Project Management and Global Systems: Building Information Systems, Managing Projects, Managing Global Systems.

Text Books:

1 Kenneth J Laudon and Jane P. Laudon, “Management Information Systems”,

Fourteenth Edition, Pearson PHI, 2016.

2 Lucey, Terry; Lucey, Terence, “Management Information Systems”, Cengage Learning EMEA,2004.

Reference Books:

1 W. S. Jawadekar, “Management Information Systems”, Third Edition, Tata McGraw Hill, 2004.

2 Kroenke, D. M., Boyle, R. J., Gemino, A., & Tingling, P., “*Experiencing MIS”,* 5th Canadian Edition), Toronto: Pearson, 2019.

Web link(s):

1 https://nptel.ac.in/courses/122/105/122105022/