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.

Credit Definition

Type	Duration (in Hour)	Credit
Lecture (L)	1	1
Tutorial (T)	1	1
Practical (P)	2	1

Total Credit

Year	Semester	hrs./Week	Credit
1st	1st	27	21
	2nd	30	23
2nd	3rd	27	23
	4th	29	23
3rd	5th	27	24
	6th	26	21
4th	7th	24	21
	8th	27	16
Total			**172**

Category Codification with Credit Break up

Definition of Category	Code	No	Credit
Major Program Core Course	MPC	1	78
Major Program Elective Course	MPE	2	14
Minor Course	MN	3	16
Multidisciplinary Course	MDC	4	12
Skill Enhancement Course	SEC	5	10
Ability Enhancement Course	AEC	6	8
Value Aided Course	VAC	7	6
Summer Training	ST	8	4
Project	PR	9	12
Vocational Course	Voc	10	12
Total			**172**

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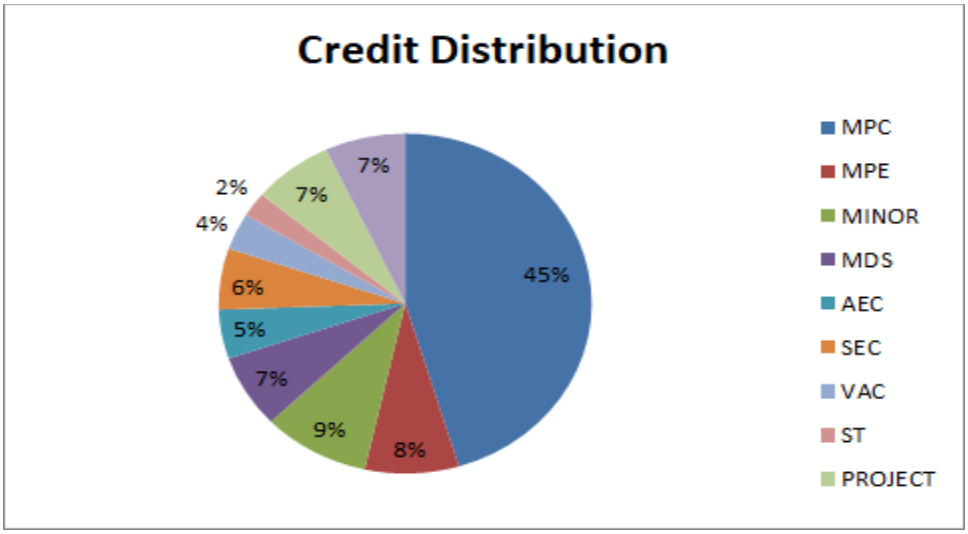
Category wise Credit Distribution



SEMESTER: I

Mandatory Induction Program – Duration 3 weeks

Physical Activity Creative Arts Universal Human Values Literary Proficiency Modules Lectures by Eminent People Visits to Local Areas Familiarization to Department/Branch & Innovations

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Sl No.	Course Name	Course Type	Course Code	Credit	Type			
					L	T	P	
1	Engineering Physics	MDS		3	3	0	0	
2	Engineering Mathematics	MDS		3	3	0	0	
3	Basic Electrical and Electronics Engineering	MPC		3	3	0	0	
4	Engineering Graphics -I	SEC		1	0	0	2	
5	Programming for problem Solving using C	MPC		3	3	0	0	
6	Physics Lab	MDS		1	0	0	2	
7	Basic Electrical and Electronics Engineering Lab	MPC		1	0	0	2	
8	Programming for problem Solving using C Lab	MPC		1	0	0	2	
9	Communicative English I	AEC		2	2	0	0	
10	NCC/YOGA	Voc NM1		1	0	0	2	
11	Vocational-Soft Skill Development-I	Voc NM2		1	0	0	2	
	Total (Major-8, MDS-7, AEC-2, SEC-1, Voc-2)			20	26HR./WEEK			

Engineering Physics: Credit 3 (3-0-0)

Module-I : Oscillation and fundamental of wave optics: Periodic motion-simple harmonic motion-characteristics of simple harmonic motion-vibration of simple springs mass system. Resonance-definition., damped harmonic oscillator – heavy, critical and light damping, energy decay in a damped harmonic oscillator, quality factor, forced mechanical and electrical oscillators.

Module-II : Basic Idea of Electromagnetisms, Maxwell's Equations: Polarization - Concept of production of polarized beam of light from two SHM acting at right angle; plane, elliptical and circularly polarized light, Brewster"s law, double refraction.

Module III: Quantum Mechanics and Crystallography: Introduction - Planck"s quantum theory- Matter waves, de- Broglie wavelength, Heisenberg"s Uncertainty principle, time independent and time dependent Schrödinger"s wave equation, Physical significance of wave function, Particle in a one dimensional potential box, Heisenberg Picture. Crystallography - Basic terms-types of crystal systems, Bravais lattices, miller indices, d spacing, Debye Scherrer powder method, laue method- Atomic packing factor for SC, BCC, FCC and HCP structures. Semiconductor Physics - conductor, semiconductor and Insulator; Basic concept of Band theory.

Module IV: Laser and Fiber optics: Einstein"s theory of matter radiation interaction and A and B coefficients; amplification of light by population inversion, different types of lasers: Ruby Laser, CO2 and Neodymium lasers; Properties of laser beams: mono-chromaticity, coherence, directionality and brightness, laser speckles, applications of lasers in engineering. Fiber optics and Applications, Types of optical fibers.

Module V: Thermodynamics: Zeroth law of thermodynamics, first law of thermodynamics, brief discussion on application of 1^{st} law, second law of thermodynamics and concept of Engine, entropy, change in entropy in reversible and irreversible processes, third law of thermodynamics.

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Text Books:

1. Beiser A, "Concepts of Modern Physics", Fifth Edition, McGraw Hill International.

2. David Halliday, Robert Resnick, Jearl Walker, "Fundamentals of Physics", Wileyplus.

Reference Books:

3. Ajoy Ghatak, "Optics" Fifth Edition, Tata McGraw Hill.

4. Sears & Zemansky, "University Physics", Addison-Wesley.

5. Jenkins and White, "Fundamentals of Optics", Third Edition, McGraw-Hill.

List of practicals:

Practical-1: Magnetic field along the axis of current carrying coil – Stewart and Gee

Practical-2: Determination of Hall coefficient of semiconductor

Practical-3: Determination of Planck constant

Practical-4: Determination of wavelength of light by Laser diffraction method

Practical-5: Determination of wavelength of light by Newton‟s Ring method

Practical-6: Determination of laser and optical fiber parameters

Practical-7: Determination of Stefan‟s Constant

Engineering Mathematics: Credit 3 (3-0-0)

Module I. Matrix and Determinants

Determinants and its properties (up to 3rd order), Minors and cofactors.

Matrices: addition, multiplication and transpose of a matrix. Symmetric and skew-symmetric matrices and their properties. Adjoint, inverse matrix, rank of a matrix, solution of Linear Equations by using Gauss Elimination, LU decomposition method.

Module II. Vector spaces

Vector space; Dimension; Basis; Orthogonality; Projections; Gram-Schmidt orthogonalization.

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Eigenvalues and Eigenvectors; Positive definite matrices; Linear transformations; Hermitian and unitary matrices.

Module III. Differential equations

Order, degree, formation of differential equations. First order differential equations – exact, non-exact, linear and Bernoulli's form. Second order differential equations with constant coefficients, method of variation of parameters, general linear differential equations with constant coefficients, system of differential equations. Simple applications of differential equations.

Module IV. Complex analysis

Complex Functions, Continuity and Differentiability of Complex Valued Functions, Cauchy-Riemann equations. Analytic functions, Zeros of analytic functions. Complex integration, Jordan's Lemma. Cauchy's theorem, Cauchy integral formula, Maximum modulus principle. Analytic continuation, Laurent series. Singularities, Classification of singularities, Cauchy's residue theorem. Evaluation of some integrals, Conformal mapping, Mobius transformation.

Text Books:

1.Higher Engineering Mathematics, B. S. Grewal, Khanna Publishers.

2.G. F.Simmons, Differential Equations, Tata Mc Graw Hill 14

3.D.A. Murray, Introductory course in Differential Equations, Orient and Longman

4.H.T. H.Piaggio, Elementary Treaties on Differential Equations and their applications

5.R. V. Churchill and J. W. Brown , Complex Variables and Applications: Mcgraw-Hill; New York; 1996

Text Books:

1.Advanced Engineering Mathematics, (Seventh Edition), Peter V. O'Neil, Cengage Learning.

2. Advanced Engineering Mathematics, (Second Edition), Michael. D. Greenberg, Pearson.

3. Introduction to linear algebra, (Fifth Edition), Gilbert Strang, Wellesley-Cambridge Press.

4.Applied Mathematics (Vol. I & II), P. N. Wartikar & J. N. Wartikar, Pune Vidyarthi Griha Prakashan.

5.S. Ponnusamy , Foundation of Complex Analysis, Narosa Publishing House, ISBN: 9788173196294

Basic Electrical and Electronics Engineering: Credit 3 (3-0-0)

UNIT I - ELECTRICAL CIRCUITS
DC Circuits: Circuit Components: Conductor, Resistor, Inductor, Capacitor – Ohm's Law - Kirchhoff's Laws, Active and passive components, Steady state analysis of RLC circuits (Simple problems only), Network theorems.

UNIT II - BASIC ELECTRONICS
Conductor, semiconductor, insulator- band diagrams, Semiconductor Materials: Silicon & Germanium. Intrinsic and extrinsic semiconductors, charge carriers, excess carriers in semiconductor, PN junction

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UNIT III - DIGITAL ELECTRONICS
Review of number systems, binary codes, boolean algebra, Logic gates, Combinational logic - representation of logic functions-SOP and POS forms, K-map representations - minimization using K maps (Simple Problems only)

UNIT IV- MEASUREMENTS AND INSTRUMENTATION
Functional elements of an instrument, Standards and calibration, Operating Principle, types -Moving Coil and Moving Iron meters, Measurement of three phase power, Oscilloscope

Text and Reference Books

1. Kothari DP and I. J. Nagrath, "Basic Electrical and Electronics Engineering", Second Edition, McGraw Hill Education, 2020
2. Ben G. Streetman and Sanjay Banerjee "Solid State Electronic Devices", PHI Learning Private Ltd.
3. S. K. Bhattacharya "Basic Electrical and Electronics Engineering", Pearson Education, Second Edition, 2017.
4. Millman & Halkias – Integrated Electronics, Tata McGraw Hill
5. Sedra & Smith -Microelectronics Engineering-Oxford
6. Boyelstad & Nashelsky - Electronic Devices & Circuit Theory – PHI
7. R. P. Jain—Modern Digital Electronics, 2/e ,McGraw Hill
8. D. RayChaudhuri- Digital Circuits-Vol-I & II, 2/e- Platinum Publishers
9. A. K. Sawhney, Puneet Sawhney 'A Course in Electrical & Electronic Measurements & Instrumentation', Dhanpat Rai and Co, 2015.

Basic Electrical and Electronics Engineering Lab: Credit 1 (0-0-2)

List of Experiments

1. Identification of components, series and parallel connections

2. Verification of Ohms and Kirchhoff's Laws.

3. Response of RC, LC and RLC circuits

4. Characteristics of PN junction Diodes

5. Study of Logic Gates

6. Universal gates

7. Implementation of boolean expressions

8. Study of DSO

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Engineering Graphics I: Credit 1(0-0-2)

Introduction to Technical Drawing Standard: Technical Drawing, ISO Standard, Paper Size, Layout, Line, Scale, Title Block, Application of lines, drawing folding, view, projection, auxiliary view.

Section and Dimension: Section and hatch, type of hatch. Coordinate and dimension, Chain dimension, Parallel dimension, Combined dimension, Coordinates dimension, Chord, Arc, Angle, Chamfer, Countersink, Dimension of Cylinder part, cubical part, sheet metal part.

Tolerance: Classification of tolerance, Linear tolerance, Angular Tolerance, Special tolerance. Tolerance indication. Bilateral and Unilateral tolerance, tolerance and fit, geometrical tolerance.

Parts, Welding and Assembly: Introduction standard parts, part drawing. Introduction to welding, welding symbols and indication to drawing, assembly drawing.

TYPES OF LINES, LETTERING & DIMENSIONING: Demonstrate and explain the use of various types of lines. Demonstrate the principle of single stroke, gothic lettering & numerals as per BIS.

SCALES Significance of scales in drawing; different scales. Define and draw plain sale and diagonal sale.

CURVES Explain Conic sections with illustration, Explain terms like focus, vertex, directrix and eccentricity. Draw conics sections by eccentricity method – Ellipse, Parabola and Hyperbola. Draw Ellipse by concentric circle method sand arc of circle method. Draw parabola by Rectangle Method and Tangent Method.

SYMBOLIC REPRESENTATION – DIFFERENT SYMBOLS USED IN THE TRADES:

Fastener (Rivets, Bolts and Nuts), Bars and profile sections, Weld, Brazed and soldered joints, Electrical and electronics element, Piping joints and fitting

FREE HAND DRAWING: Lines, polygons, ellipse etc., Geometrical figures and blocks with dimension, Transferring measurement from the given object to the free hand sketches. Solid objects – Cube, Cuboids, Cone, Prism, Pyramid, Frustum of Cone with dimensions. Free hand drawing of hand tools and measuring tools, simple fasteners (nuts, bolts, rivets etc.) trade related sketches.

Text Books:

1. “Technical Drawing”, Authors: Giesecke, Mitchell, Spencer, Hill, Dygdon, Novak, Publisher: Pearson, Prentice Hall, ISBN:0-13-178446-3

2. “Technical Drawing”, Publisher: ISO Standard Handbook, ISBN: 178446 – 3

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Fundamentals of Computer Sc. & Problem Solving using C: Credit 3 (3-0-0)

Introduction to Computers: Computer Systems, Computing Environments, Computer Languages, Creating and Running Programs, Software Development, Flow charts.

Number Systems: Binary, Octal, Decimal, and Hexadecimal.

Problem Solving approach: Algorithm, structure of algorithm, running time, formulate simple algorithm for arithmetic and logical problems.

Imperative languages: Introduction to python programming language; syntax and constructs of a specific language.

Types Operator and Expressions with discussion of variable naming and Hungarian Notation: Variable Names, Data Type and Sizes, Constants, Declarations, Arithmetic Operators, Relational Operators, Logical Operators, Type Conversion, Increment Decrement Operators, Bitwise Operators, Assignment Operators and Expressions, Precedence and Order of Evaluation.

Control Flow with discussion on structured and unstructured programming: Statements and Blocks, If-Else statement, Loops: while, do-while, for. Concept of break, continue and pass statement.

Functions and Program Structure with discussion on standard library: Basics of functions, parameter passing and returning type, Block structure, Initialization, Recursion and return types. Concept of module and packages. Basic concepts of tuple, list, dictionary and string. Linear and Binary Search, Selection and Bubble Sort. File handling

Text Books:

1. Byron S Gottfried “Programming with C” Second edition, Tata McGrawhill, 2007, (Paper back)

2. R.G. Dromey, “How to solve it by Computer”, Pearson Education, 2008.

3. Kanetkar Y, “Let us C”, BPB Publications, 2007.

4. Hanly J R & Koffman E.B, “Problem Solving and Programm design in C”, Pearson

Education, 2009.

Reference Books:

1. E. Balagurusamy, “Programming with ANSI-C”, Fourth Edition,2008, Tata McGraw Hill.

2. Venugopal K. R and Prasad S. R, “Mastering ‘C’”, Third Edition, 2008, Tata McGraw Hill.

3. B.W. Kernighan & D. M. Ritchie, “The C Programming Language”, Second Edition, 2001,

Pearson Education

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4. ISRD Group, "Programming and Problem Solving Using C", Tata McGraw Hill,2008.

5. Pradip Dey , Manas Ghosh, "Programming in C", Oxford University Press, 2007

List of practical

Practical-1: Algorithm and flowcharts of small problems like GCD

Practical-2: Structured code writing with: Small but tricky codes

Practical-3: Proper parameter passing

Practical-4: Command line Arguments

Practical-5: Variable parameter

Practical-6: Make file utility

Practical-7: Multi module program

Communicative English I: Credit 2(2-0-0)

Grammar:

Noun and Pronoun (Types and Functions), Verbs (Lexical and Auxiliary), Verb Tenses, Adjectives and Adverb, Article and Preposition, Conjunction, Phrases, Clause (Noun, Adjective, Adverb), Sentence Types (Simple, Compound and Complex), Transformations (Active-Passive, Direct-Indirect)

Vocabulary:

One-word Substitution, Homophones, Proverbs, Synonyms and Antonyms

Phonetics:

Air-stream Mechanism, Vowel and Consonant Sounds, Intonation

Communication Theory:

Definition of Communication, Types of Communication (Verbal & Non-Verbal; Formal & Informal; Intra-personal, Inter-personal, Extra-personal, Group, Mass), Flows of Communication (Vertical, Horizontal and Diagonal), Barriers of Communication

Comprehension:

Reading and Comprehension, Objective and Subjective Questions.

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Text Books:

1. Intermediate English Grammar- Cambridge University Press
2. High School English Grammar- Wren and Martin

Reference Books:

3. English vocabulary in use – Alan Mc‟carthy and O‟dell
4. APAART: Speak Well 1 (English language and communication)
5. APAART: Speak Well 2 (Soft Skills)

SEMESTER: II

Sl No.	Course Name	Course Type	Course Code	Credit	Type		
					L	T	P
1	Engineering Chemistry	MDS		3	3	0	0
2	Numerical Analysis and Optimisation Technique	MPC		3	3	0	0
3	Electronic Devices	MPC		3	3	0	0
4	Engineering Graphics -II	SEC		1	0	0	2
5	Introduction to Python	MPC		3	3	0	0
6	Chemistry Lab	MDS		1	0	0	2
7	Numerical Analysis and Optimisation Technique Lab	MPC		1	0	0	2
8	Electronic Devices Lab	MPC		1	0	0	2
9	Introduction to Python Lab	MPC		1	0	0	2
10	Communicative English II	AEC		2	2	0	0
11	Environmental Science	VAC		2	2	0	0
12	Vocational-Soft Skill Development-II	VocNM3		1	0	0	2
13	NCC/YOGA	Voc NM4		1	0	0	2
	Total (Major-8, MSD-4, AEC-2, SEC-5, VAC-2,Voc -2)			23	30Hrs./Week		

Engineering Chemistry: Credit 3 (3-0-0)

Thermodynamics of Chemical Processes: Concept of entropy, Chemical potential, Equilibrium conditions for closed systems, Phase and reaction equilibria, Maxwell relations, Real gas and real solution.

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Electrochemical Systems: Electrochemical cells and EMF, Applications of EMF measurements: Thermodynamic data, activity coefficients, solubility product and pH, corrosion.

Kinetics of Chemical Reactions: Reversible, consecutive and parallel reactions, Steady state approximation, Chain reactions, Photochemical kinetics.

Bonding Models in Inorganic Chemistry: Molecular orbital theory, Valence-bond theory, Crystal field theory.

Fundamentals of Microwave, IR and UV-VIS Spectroscopy: Basic concepts of spectroscopy, Selection rule, Determination of molecular structure.

Coordination Chemistry: Coordination numbers, Chelate effect, Coordination complexes and application, Bio-inorganic chemistry: Metal ions in Biological systems, environmental aspects of Metals, NOx, CO, CO2.

Organic Reaction Mechanism: Mechanisms of selected organic, bio-organic, polymerization and catalytic reactions. Stereochemistry of Carbon Compounds: Selected Organic Compounds: Natural products and Biomolecules (Amino acids/nucleic acids/proteins).

Laboratory Component:

Surface tension and parachor, Measurement of the coefficient of viscosity: CMC of a surfactant, Conductometric titration, pH-metric/potentiometric titration, Solubility product, Kinetics of ester hydrolysis, Estimation of Fe2+, EDTA titration, Estimation of base content and acid content of commercially available antacid and vitamin C respectively, Synthesis of Mohr‟s salt, Synthesis of aspirin, Demonstration of a few important physico-chemical processes. (e.g. Gel electrophoresis, Oscillatory reactions)

Text Books:

1. Engineering Chemistry, Satyaprakash, Khanna Book Publishing, Delhi

2. Chemistry: Principles and Applications, by M. J. Sienko and R. A. Plane

3. Fundamentals of Molecular Spectroscopy, by C. N. Banwell

Reference Books:

4. Engineering Chemistry (NPTEL Web-book), by B. L. Tembe, M. S. Krishnan

5. Physical Chemistry, P. C. Rakshit, Sarat Book House

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Numerical Analysis and Optimisation Technique: credit 3 (3-0-0)

Module I

Approximation in numerical computation: Truncation and rounding errors, Fixed and floating-point arithmetic, Propagation of errors. Interpolation: Newton forward/backward interpolation, Lagrange's and Newton's divided difference Interpolation. Numerical integration: Trapezoidal rule, Simpson's 1/3 rule, Expression for corresponding error terms.

Module II

Numerical solution of a system of linear equations: Gauss elimination method, Matrix inversion, LU Factorization method, Gauss-Seidel iterative method. Numerical solution of Algebraic equation: Bisection method, Regula-Falsi method, Newton-Raphson method.

Module III

Numerical solution of ordinary differential equation: Euler's method, Runge-Kutta methods, Predictor-Corrector methods and Finite Difference method.

Module IV

INTRODUCTION : Concept of optimization – classification of optimization

Module V

LINEAR PROGRAMMING: Examples of linear programming problems –formulation simplex methods variable with upper bounds – principle duality –dual simplex method - sensitivity analysis – revised simplex procedure – solution of the transportation problem – assignment – network minimization – shortest route problem.

Module VI

QUEUING THEORY: Queuing Model, poisson and exponential distributions –Queues with combined arrivals and departures-random and series queues.

Module VII

UNCONSTRAINED OPTIMIZATION: Maximization and minimization of convex functions. Necessary and sufficient conditions for local minima – speed and order of convergence – unibariate search – steepest and descent methods

Unit VIII

CONSTRAINED OPTIMIZATION: Necessary and sufficient condition – equality constraints, inequality constraints - kuhu – tucker conditions – gradient projection method.

Text Books:

1. C.Xavier: C Language and Numerical Methods.

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2. Dutta & Jana: Introductory Numerical Analysis.

3. J.B.Scarborough: Numerical Mathematical Analysis.

4. Jain, Iyengar , & Jain: Numerical Methods (Problems and Solution).

5. Rao S.S,"Optimization Theory and applications", Wiley Easter Ltd., 1979.

6. David G.Luerbeggan, "Introduction to Linear and Non Linear

Programming", Addison Wesley Publishing Co. 1973.

References:

1. Balagurusamy: Numerical Methods, Scitech.

2. Baburam: Numerical Methods, Pearson Education.

3. N. Dutta: Computer Programming & Numerical Analysis, Universities Press.

4. Soumen Guha & Rajesh Srivastava: Numerical Methods, OUP.

5. Srimanta Pal: Numerical Methods,

6. Cordan C.C. Beveridge and Robert S. Schedther, "Optimization, Theory and Practice" McGraw Hill Co.1970

List of Experiments

1. Introduction to Software Packages: Matlab / Scilab / Labview / Mathematica

2. Assignments on Newton forward /backward, Lagrange's interpolation.

3. Assignments on numerical integration using Trapezoidal rule, Simpson's 1/3 rule.

4. Assignments on numerical solution of a system of linear equations using Gauss elimination and Gauss-Seidel iterations.

5. Assignments on numerical solution of Algebraic Equation by Regular-falsi and Newton Raphson methods.

6. Assignments on ordinary differential equation: Euler's and Runga-Kutta methods.

7. Verify the descent conditions for a given search direction for unconstrained optimization problem and calculate step size along search direction using Equal Interval Search method numerically and verify results by using MATLAB

8. Solve nonlinear optimization problems by using numerical optimization methods (indirect) steepest-descent and verify the results by using MATLAB

9. Solve LPP by two-phase simplex method numerically and verify the results by using MATLAB

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Electronic Devices: Credit 3 (3-0-0)

Introduction to Semiconductor Physics: Review of Quantum Mechanics, Electrons in periodic Lattices, E-k diagrams.

Energy bands in intrinsic and extrinsic silicon; Carrier transport: diffusion current, drift current, mobility and resistivity; sheet resistance, design of resistors

Generation and recombination of carriers; Poisson and continuity equation P-N junction characteristics, I-V characteristics, and small signal switching models; Avalanche breakdown, Zener diode, Schottky diode

Bipolar Junction Transistor, I-V characteristics, Ebers-Moll Model.

MOS capacitor, C-V characteristics, MOSFET, I-V characteristics, and small signal models of MOS transistor.

LED, photodiode and solar cell.

Text /Reference Books:

1. Ben G. Streetman, and S. K. Banerjee, “Solid State Electronic Devices,” 7th edition, Pearson, 2014.
2. D. Neamen , D. Biswas "Semiconductor Physics and Devices," McGraw-Hill Education
3. S. M. Sze and K. N. Kwok, “Physics of Semiconductor Devices,” 3rd edition, John Wiley &Sons, 2006.
4. C.T. Sah, “Fundamentals of solid state electronics,” World Scientific Publishing Co. Inc, 1991. 5. Y. Tsividis and M. Colin, “Operation and Modeling of the MOS Transistor,” Oxford Univ.Press, 2011.

Laboratory Experiments:

1. CHARACTERISTICS OF PN JUNCTION DIODE

a) To Plot the Volt Ampere Characteristics of PN Junction Diode under Forward and Reverse Bias Conditions.
b) To find the Cut-in voltage, Static Resistance, Dynamic Resistance for Forward Bias & Reverse Bias

2. CHARACTERISTICS OF ZENER DIODE & LOAD REGULATION

a) To Obtain the Forward Bias and Reverse Bias characteristics of a Zener diode.
b) Find out the Zener Breakdown Voltage from the Characteristics.
c) To Obtain the Load Regulation Characteristics.

3. COMMON BASE BIPOLAR TRANSISTOR CHARACTERISTICS

a) To plot the Input and Output characteristics of a transistor connected in Common Base Configuration

4. COMMON EMITTER BIPOLAR TRANSISTOR CHARACTERISTICS

a) To plot the Input and Output characteristics of a transistor connected in Common Emitter

5. JFET DRAIN & TRANSFER CHARACTERISTICS (COMMON SOURCE)

a) Drain characteristics
b) Transfer Characteristics.
c) To find rd, gm, and μ from the characteristics.

6. Study Characteristics of Photo transistor
7. Study Characteristics of LED & LDR

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Engineering Graphics II Credit 1 (0-0-2)

OTHOGRAPHIC PROJECTIONS: Demonstrate the principles of 1st angle and 3rd angle projections with the help of models and draw symbols.

PROJECTION OF POINTS AND LINES: Draw projection of points, Draw projection of straight line (parallel to both planes, parallel to one and perpendicular to other, parallel to one and inclined to other and inclined to both reference planes).

PROJECTION OF PLANES: Draw plane figure such as squares, rectangles, triangles, circle, Pentagon and hexagon (perpendicular to one plane and inclined to other).

PROJECTIONS OF SOLIDS: Draw projections of solids such as prism, cylinder, cone, tetrahedron and pyramid in simple position (with axis parallel to one reference plane and perpendicular to other reference plane).

ISOMETRIC PROJECTIONS Draw isometric view & Isometric projection of prism, pyramid, cone & cylinder with axis horizontal and vertical with construction of isometric scales.

PRACTICES ON AutoCAD Introduction-Settings, Limits etc. Auto CAD commands: Draw commands (Line, circle, are polygon, ellipse, rectangle). Edit command, Dimension commands and Modify Commands for two dimensional drafting only. Exercise for practice using Auto CAD.

Orthographic projections of lines, planes sand solids as per previous chapter, Isometric projection.

Books Recommended

1. Machine Drawing by Basudeb Bhattacharya, Oxford University Press.
2. A Text Book of Engineering Drawing by Dr. R.K. Dhawan.
3. A Text Book of Engineering Graphics & Auto CAD by K Venugopal.
4. A Text book of Engineering Drawing by N.D. Bhatt.
5. Engineering Drawing by P.S. Gill.
6. An Introduction to Auto CAD – 2012 by George Omura, Willey India Publishers.

Introduction to Python 3(3-0-0)

Introduction, Python Basics: Entering Expressions into the Interactive Shell, The Integer, Floating-Point, and String Data Types, String Concatenation and Replication, Storing Values in Variables, Your First Program, Dissecting Your Program.

Flow control: Boolean Values, Comparison Operators, Boolean Operators, Mixing Boolean and Comparison Operators, Elements of Flow Control, Program Execution, Flow Control Statements, Importing Modules, Ending a Program Early with sys.exit()

Functions: def Statements with Parameters, Return Values and return Statements, The None Value, Keyword Arguments and print(), Local and Global Scope, The global Statement, Exception Handling.

Lists: The List Data Type, Working with Lists, Augmented Assignment Operators, Methods

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Dictionaries and Structuring Data: The Dictionary Data Type, Pretty Printing, Using Data Structures to Model Real-World Things.
Manipulating Strings - Working with Strings, Useful String Methods.

Pattern Matching with Regular Expressions: Finding Patterns of Text without Regular Expressions, Finding Patterns of Text with Regular Expressions, More Pattern Matching with Regular Expressions, Greedy and
Nongreedy Matching, The findall() Method, Character Classes, Making Your Own Character Classes, The Caret and Dollar Sign Characters, The Wildcard Character, Review of Regex Symbols, Case-Insensitive Matching,
Substituting Strings with the sub() Method, Managing Complex Regexes, Combining re.IGNORECASE, re .DOTALL, and re .VERBOSE.

Reading and Writing Files: Files and File Paths, The os.path Module, The File Reading/Writing Process, Saving Variables with the shelve Module, Saving Variables with the pprint.pformat() Function.
Organizing Files: The shutil Module, Walking a Directory Tree, Compressing Files with the zipfile Module.

Web Scraping: Project: MAPIT.PY with the web browser Module, Downloading Files from the Web with the requests Module, Saving
Downloaded Files to the Hard Drive, HTML.
Working with Excel Spreadsheets: Excel Documents, Installing the openpyxl Module, Reading Excel Documents, Project: Reading Data from a Spreadsheet, Writing Excel Documents, Project: Updating a Spreadsheet, Setting the Font Style of Cells, Font Objects, Formulas, Adjusting Rows and Columns, Charts.

Text Book:

1. Al Sweigart, “Automate the Boring Stuff with Python”, William Pollock, 2015, ISBN: 978-1593275990.
2. Allen B. Downey, "Think Python: How to Think Like a Computer Scientist”, 2nd Edition, Green Tea Press, 2015, ISBN: 978-9352134755.
3. Charles Dierbach, "Introduction to Computer Science Using Python", 1st Edition, Wiley India Pvt Ltd. ISBN-13: 978-8126556014.

Laboratory Experiments:

A) Write a program to create a menu with the following operations

1. TO PERFORM ADDITITON

2. TO PERFORM SUBSTRACTION

3. TO PERFORM MULTIPICATION

4. TO PERFORM DIVISION

Accepts users input and performs the operation accordingly. Use functions with arguments.

B) Write a python program to check whether the given string is palindrome or not.

C) Write a python program to find factorial of a given number using functions

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D) Write a Python function that takes two lists and returns True if they are equal otherwise false

1. Write a program to double a given number and add two numbers using lambda()?

2. Write a program for filter() to filter only even numbers from a given list.

3. Write a program for map() function to double all the items in the list?

4. Write a program to find sum of the numbers for the elements of the list by using reduce()?

5. A) Demonstrate a python code to implement abnormal termination?

B) Demonstrate a python code to print try, except and finally block statements

C) Write a python program to open and write “hello world” into a file

6. A) Write a python program to get python version.

B) Write a python program to open a file and check what are the access permissions acquired by that file using os module?

C) Write a python program to display a particular month of a year using calendar module.

D) Write a python program to print all the months of given year.

7. A) Write a python program to print date, time for today and now.

B) Write a python program to add some days to your present date and print the date added.

C) Write a python program to print date, time using date and time functions

D) Write a python program which accepts the radius of a circle from user and computes the area (use math module).

8. A) Write a python program to create a package (college),sub-package (alldept),modules(it,cse) and create admin and cabin function to module?

B) Write a python program to create a package(Engg), sub- package(years),modules (sem) and create staff and student function to module?

9. A) Write a python Program to display welcome toMRCET by using classes and objects.

B) Write a python Program to call data member and function using classes and objects

C) Write a program to find sum of two numbers using class and methods

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D) Write a program to read 3 subject marks and display pass or failed using class and object.

10. A) Using a numpy module create an array and check the following:

1. Type of array

2. Axes of array

3. Shape of array

4. Type of elements in array

B) Using a numpy module create array and check the following:

1. List with type float

2. 3*4 array with all zeros

3. From tuple

4. Random values

C) Using a numpy module create array and check the following:

1. Reshape 3X4 array to 2X2X3 array

2. Sequence of integers from 0 to 30 with steps of 5

3. Flatten array

4. Constant value array of complex

11 A) Write a python program to concatenate the data frames with two different objects

B) Write a python code to read a csv file using the pandas module and print the first and last five lines of a file.

12. A) Write a python code to set background color and pic and draw a circle using turtle module

B) Write a python code to set background color and pic and draw a square and fill the color using turtle module

C) Write a python code to perform addition using functions with the pdb module.

Communicative English – II Credit 2 (2-0-0)

Grammar:

Verbs- Gerund, Participle, Infinitives, Modal Verbs; Adjectives- Degree of Comparison, Transformation (Positive, Comparative, Superlative); Moods - Declarative, Imperative, Exclamatory, Interrogative, Subjunctive, Optative, Conditional; Prepositions- Simple, Compound, Phrase

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Vocabulary:

One-word Substitution, Homophones, Figures of Speech (simile, metaphor), Business Idioms

Communication Theory:

Audience Analysis, 7 Cs of Communication, SWOT Analysis

Comprehension:

1. Reading and Comprehension, Objective and Subjective Questions

2. Understanding Visual Data- Graphs, Charts, Tables

Writing:

Business Letters- Application, Complaints, Order, Collection, Sales Promotional Letter; Notice, Memorandum, Agenda, Minutes, Advertisements.

Text Books

1. High School English Grammar by Wren and Martin

2. Developing Communication Skills by Krishna Mohan and Meera Banerji

Reference Books:

3. Technical Communication- Meenakshi Raman and Sangeeta Sharma

4. Professional Communication by Ashraf Rizvi

SEMESTER: III

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Sl No.	Course Name	Course Type	Course Code	Credit	Type		
					L	T	P
1	Digital System Design	MPC		3	3	0	0
2	Signals & Systems	MPC		3	3	0	0
3	Network Theory	MPC		3	3	0	0
4	Probability Theory and Stochastic Process	MPC		3	2	1	0
5	Data Structure & Algorithm	SEC		3	3	0	0
6	Digital System Design Lab	MPC		1	0	0	2
7	Signals & Systems Lab	MPC		1	0	0	2
8	Data Structure & Algorithm Lab	SEC		1	0	0	2
9	Basic Management	VAC		3	3	0	0
10	Foreign Language - I - Spanish	AEC		2	2	0	0
	Foreign Language - I - German						
	Foreign Language - I - Japanese						
	Foreign Language - I - French						
11	Vocational-Soft Skill Development-III	Voc NM5		1	0	0	2
	Total (Major-14, SEC-4, AEC-2, VAC-2, Voc-1)			**24**	**28Hrs./Week**		

Digital system Design: Credit 4 (3-1-0)

Logic Simplification and Combinational Logic Design: Review of Boolean Algebra and De Morgan's Theorem, SOP & POS forms, Canonical forms, Karnaugh maps up to 6 variables, Binary codes, Code Conversion.

MSI devices like Comparators, Multiplexers, Encoder, Decoder, Driver & Multiplexed Display, Half andFull Adders, Subtractors, Serial and Parallel Adders, BCD Adder, Barrel shifter and ALU

Sequential Logic Design: Building blocks like S-R, JK and Master-Slave JK FF, Edge triggered FF, Ripple and Synchronous counters, Shift registers, Finite state machines, Design of synchronous FSM,Algorithmic State Machines charts. Designing synchronous circuits like Pulse train generator, Pseudo Random Binary Sequence generator, Clock generation

Logic Families and Semiconductor Memories: TTL NAND gate, Specifications, Noise margin, Propagation delay, fan-in, fan-out, Tri-state TTL, ECL, CMOS families and their interfacing, Memory elements, Concept of Programmable logic devices like FPGA. Logic implementation using Programmable Devices.

VLSI Design flow: Design entry: Schematic, FSM & HDL, different modeling styles in VHDL, Data types and objects, Dataflow, Behavioral and Structural Modeling, Synthesis and Simulation VHDL constructs and codes for combinational and sequential circuits.

Text/Reference Books:

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1. R.P. Jain, "Modern digital Electronics", Tata McGraw Hill, 4th edition, 2009.
2. Douglas Perry, "VHDL", Tata McGraw Hill, 4th edition, 2002.
3. W.H. Gothmann, "Digital Electronics- An introduction to theory and practice", PHI, 2nd edition ,2006.
4. D.V. Hall, "Digital Circuits and Systems", Tata McGraw Hill, 1989
5. Charles Roth, "Digital System Design using VHDL", Tata McGraw Hill 2nd edition 2012.

Laboratory Experiments:

1. Introduction to Digital Electronics Lab- Nomenclature of Digital Ics, Specifications, Study of the Data Sheet, Concept of Vcc and Ground, Verification of the Truth Tables of Logic Gates using TTL ICs.
2. Implementation of the Given Boolean Function using Logic Gates in Both Sop and Pos Forms.
3. Verification of State Tables of Rs, J-k, T and D Flip-Flops using NAND & NOR Gates
4. Implementation and Verification of Decoder/De-Multiplexer and Encoder using Logic Gates.
5. Implementation of 4x1 Multiplexer using Logic Gates.
6. Implementation of 4-Bit Parallel Adder Using 7483 IC.
7. Design , and Verify the 4- Bit Synchronous Counter
8. Design, and Verify the 4-Bit Asynchronous Counter.
9. Simulation of MOS Inverter with different loads using PSPICE software
10. Simulation of CMOS Inverter for different parameters Kn, Kp as a design variable in suitable circuit simulator software.
11. Design of a 4-bit Multiplexer using VHDL\Verilog
12. Design of a decade counter using VHDL\Verilog.
13. Design of a 3-input NAND gate and its simulation using suitable logic simulator

Signals and Systems Credit 3 (3-0-0)

Continuous and discrete time signals, continuous and discrete amplitude signals, Energy and power signals, System properties: linearity: additively and homogeneity, shift-invariance, causality, stability, reliability.

Linear shift-invariant (LSI) systems, impulse response and step response, convolution, input output behavior with aperiodic convergent inputs. Characterization of causality and stability of linear shift-invariant systems. System representation through differential equations and difference equations.

Periodic and semi-periodic inputs to an LSI system, the notion of a frequency response and its relation to the impulse response, Fourier series representation, the Fourier Transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response, Fourier domain duality. The Discrete-Time Fourier Transform (DTFT) and the Discrete Fourier Transform (DFT). Parseval's Theorem. The idea of signal space and orthogonal bases,

The Laplace Transform, notion of eigen functions of LSI systems, a basis of eigen functions, region of convergence, poles and zeros of a system, Laplace domain analysis, solution to differential equations and system behavior.

The z-Transform for discrete time signals and systems- eigen functions, region of convergence, z-domain analysis.

State-space analysis and multi-input, multi-output representation. The state-transition matrix and its role. The Sampling Theorem and its implications- Spectra of sampled signals. Reconstruction: ideal interpolator, zero-order hold, first-order hold, and so on. Aliasing and its effects. Relation between continuous and discrete time systems.

Text/Reference books:

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1. A.V. Oppenheim, A.S. Willsky and I.T. Young, "Signals and Systems", Prentice Hall, 1983.
2. R.F. Ziemer, W.H. Tranter and D.R. Fannin, "Signals and Systems - Continuous and Discrete", 4th edition, Prentice Hall, 1998.
3. Papoulis, "Circuits and Systems: A Modern Approach", HRW, 1980.
4. B.P. Lathi, "Signal Processing and Linear Systems", Oxford University Press, c1998.
5. Douglas K. Lindner, "Introduction to Signals and Systems", McGraw Hill International Edition: c1999.

Laboratory Experiments:.
1.GENERATIN OF VARIOUS SIGNALS AND SEQUENCE

2. OPERATION ON SIGNALS AND SEQUENCES

3. FOURIER TRANSFORMS AND INVERSE FOURIER TRANSFORM

4. PROPERTIES OF FOURIER TRANSFORMS
5. LAPLACE TRANSFORMS
6. Z-TRANSFORMS
7.CONVOLUTION BETWEEN SIGNALS AND SEQUENCES
8.. AUTO CORRELATION AND CROSS CORRELATION
9.. GAUSSIAN NOISE
10.DISTRIBUTION AND DENSITY FUNCTIONS OF STANDARD RANDOM VARIABLES
11. WIDE SENSE STATIONARY RANDOM PROCESS.

Network Theory: Credit 3 (3-0-0)

Node and Mesh Analysis, matrix approach of network containing voltage and current sources, and reactances, source transformation and duality.Network theorems: Superposition, reciprocity, Thevenin's, Norton's, Maximum power Transfer, compensation and Tallegen's theorem as applied to AC. circuits. Trigonometric and exponential Fourier series: Discrete spectra and symmetry of waveform, steady state response of a network to non-sinusoidal periodic inputs, power factor, effective values, Fourier transform and continuous spectra, three phase unbalanced circuit and power calculation.

Laplace transforms and properties: Partial fractions, singularity functions, waveform synthesis, analysis of RC, RL, and RLC networks with and without initial conditions with Laplace transforms evaluation of initial conditions.

Transient behavior, concept of complex frequency, Driving points and transfer functions poles and zeros of immittance function, their properties, sinusoidal response from pole-zero locations, convolution theorem and Two four port network and interconnections, Behaviors of series and parallel resonant circuits, Introduction to band pass, low pass, high pass and band reject filters.

Text/Reference Books
1. Van, Valkenburg.; "Network analysis"; Prentice hall of India, 2000
2. Sudhakar, A., Shyammohan, S. P.; "Circuits and Network"; Tata McGraw-Hill New Delhi, 1994
3. A William Hayt, "Engineering Circuit Analysis" 8th Edition, McGraw-Hill Education

Probability Theory and Stochastic Processes 3(3-0-0)

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Module 1: Basic Probability: 8L
Probability spaces, conditional probability, independence; Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality.

Module 2: Continuous Probability Distributions: 4L
Continuous random variables and their properties, distribution functions and densities, normal, exponential and uniform distribution.

Module 3: Bivariate Distributions: 4L
Bivariate distributions and their properties, distribution of sums and quotients, conditional densities, Bayes' rule.

Module 4 : Introduction to Stochastic Process (SP) 2L
Definition and examples of SPs, classification of random processes according to state space and parameter space, types of SPs, elementary problems.

Module 5: Stationary Process: 2L
Weakly stationary and strongly stationary processes, moving average and auto regressive processes.

Module 6: Discrete-time Markov Chains: 4L
Chapman–Kolmogorov equations, classification of states, limiting probabilities, mean time in transient states, applications.

Module 7: Continuous-time Markov chains : 4L
Kolmogorov- Feller differential equations, infinitesimal generator, Poisson process, birth-death process, stochastic Petri net, applications to queueing theory and communication networks.

Module 8: Brownian Motion : 4L
Wiener process as a limit of random walk; process derived from Brownian motion, Stochastic Differential Equation(SDE). Some important SDEs and their solutions.

Text and Reference Books:
(i) Peyton Z. Peebles, Probability, Random Variables & Random Signal Principles, TMH, 4th Edition, 2001.
(ii) Donald Childers,Probability and Random Processes-Scott Miller, 2Ed,Elsevier,2012
(iii) Pradip Kumar Gosh, Theory of probability and Stochastic Processes, University Press
(iv) P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Probability Theory, Universal Book Stall, 2003 (Reprint).
(v) S. Ross, A First Course in Probability, 6th Ed., Pearson Education India, 2002.
(vi) W. Feller, An Introduction to Probability Theory and its Applications, Vol. 1, 3rd Ed., Wiley, 1968.
(vii) Liliana Blanco Castaneda, Viswanathan Arunachalam and S. Dharmaraja, Introduction to Probability and Stochastic Processes with Applications, Wiley, 2012.

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Data Structures & Algorithm Credit 3(3-0-0)

Basic Terminologies & Introduction to Algorithm and Data Organization: [6L]
Algorithm specification, Recursion, Performance analysis, Asymptotic Notation - The Big-O, Omega and Theta notation, Programming Style, Refinement of Coding - Time-Space Trade Off, Testing, Data Abstraction.

Linear Data Structure: [10L]

Array, Stack, Queue, Linked-list and its types, Various Representations, Operations & Applications of Linear Data Structures.

Non-linear Data Structure: [10L]

Trees (Binary Tree, Threaded Binary Tree, Binary Search Tree, B & B+ Tree, AVL Tree, Splay Tree) and Graphs (Directed, Undirected), Various Representations, Operations (search and traversal algorithms and complexity analysis) & Applications of Non-Linear Data Structures.

Searching and Sorting on Various Data Structures: [10L]

Sequential Search, Binary Search, Breadth First Search, Depth First Search, Insertion Sort, Selection Sort, Shell Sort, Divide and Conquer Sort, Merge Sort, Quick Sort, Heap Sort, Introduction to Hashing

Text/Reference Books:

1. Data Structures using C and C++ by Y. Langsam, M. J. Augenstein, A.M. Tanenbaum, Prentice Hall of India 2. Classic Data Structures by D. Samanta, Prentice Hall of India

3. Data Structures by S. Lipschutz, Tata McGraw Hill

4. Introduction to Algorithms by T.H. Cormen, C.E. Leiserson, R.L. Rivest and C. Stein, Prentice Hall of India

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SEMESTER: IV

Sl No.	Course Name	Course Type	Course Code	Credit	Type		
					L	T	P
1	Analog Electronics	MPC		3	3	0	0
2	Analog & Digital Communication	MPC		3	3	0	0
3	Microprocessor and Microcontroller	MPC		3	3	0	0
4	Computer Organisation and Architecture	MPC		3	3	0	0
5	Database Management System (DBMS)	SEC		3	3	0	0
6	Analog Electronics Lab	MPC		1	0	0	2
7	Analog & Digital Communication Lab	MPC		1	0	0	2
8	Microprocessor and Microcontroller Lab	MPC		1	0	0	2
9	Computer Architecture Lab	MPC		1	0	0	2
10	Database Management System (DBMS) Lab	SEC		1	0	0	2
11	Foreign Language - II - Spanish						
	Foreign Language - II - German						
	Foreign Language - II - Japanese						
	Foreign Language - II - French	AEC		2	2	0	0
12	Vocational-Soft Skill Development-IV	Voc NM6		1	0	0	2
	Total (Major-16, AEC-2, SEC-4, Voc-1)			**23**	**29 Hrs./Week**		

Analog Electronics Credit 3 (3-0-0)

Introduction to Electronic Circuits
Diode & wave shaping circuits: Different rectifier circuits, ripple factor, efficiency, TUF, PIV, power supply filters, clipper and clamper circuits, peak detector, voltage multiplier. RC filter response for non sinusoidal signals

BJT circuits: Biasing and stability analysis: fixed bias, collector to base feedback bias, emitter bias, voltage divider bias, transistor as a switch,
Hybrid Parameters, Frequency response: Low frequency and high frequency response, Miller effect,brief overview on multistage amplifier,

FET circuits: Biasing: fixed bias, self-bias, voltage divider bias, common drain, common gate configurations, AC analysis: Modeling (small signal model), expressions for input impedance, output impedance, voltage gain for different configurations like fixed bias, self-bias, voltage divider bias, common drain, common gate configurations Frequency response: low frequency and high frequency response, Miller effect .

Multistage amplifiers: Cascaded BJT and FET amplifiers, frequency response of R-C coupled multi- stage amplifier.

Feedback concepts, connection types, practical circuits, phase and frequency considerations.

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OPAMP circuits: Basics, differential amplifier circuit, concept of open loop and closed loop gain, DC offset and frequency parameters, slew rate, differential and common mode operation , applica- tions: inverting and non-inverting amplifier, transresistance amplifier, transconductance amplifier, log and antilog amplifier, adder, subtractor, multiplier, divider, buffer, differentiator and integrator, active filters, Equation solver, Schmitt trigger and multivibrators, rectifier clipper and clamper circuits, peak detector.

Regulated Power Supply: Voltage regulation, Zener diode & IC regulator, regulation factor, filter circuit‘s discrete transistor voltage regulation (series and shunt), switching regulators, switch mode power supply.

Text Books:

1. J. Millman, C. Halkias and S. Jit, ‖Electronic Devices and Circuits‖, Tata McGrawHill, 4th edition, 2015.
2. Adel S. Sedra and Kenneth C. Smith, ‖Microelectronic Circuits-Theory and applications‖, seventh Edition , 2017
3. Thomas L. Floyd, David M. Buchla, ‖Fundamentals of Analog Circuits‖, Pearson, 2nd Edn

Laboratory Experiments:

1. Conduct experiment to test diode clipping (single/double ended) and clamping circuits (positive/negative).
2. Design and set up the following rectifiers with and without filters and to determine ripple factor and rectifier efficiency:
   (a). Full Wave Rectifier (b). Bridge Rectifier
3. Design and set up the BJT common emitter amplifier using voltage divider bias with and without feedback and determine the gain- bandwidth product from its frequency response.
4. Set-up and study the working of complementary symmetry class B push pull power amplifier and calculate the efficiency
5. Realize BJT Darlington Emitter follower with and without bootstrapping and determine the gain, input and output impedances
6. Conduct an experiment on Series Voltage Regulator using Zener diode and power transistor to determine line and load regulation characteristics.
7. Design and set-up the following tuned oscillator circuits using BJT, and determine the frequency of oscillation.
8. R-C Phase shift Oscillator/Wien Bridge Oscillator
9. Plot the transfer and drain characteristics of n-channel MOSFET and calculate its parameters, namely; drain resistance, mutual conductance and amplification factor.
10. Design, setup and plot the frequency response of Common Source JFET/MOSFET amplifier and obtain the bandwidth.

Analog and Digital Communication Credit 3 (3-0-0)

UNIT I ANALOG COMMUNICATION

Introduction to Communication Systems – Modulation – Types – Need for Modulation. Theory of Amplitude Modulation – Evolution and Description of SSB Techniques – Theory of Frequency and Phase Modulation – Comparison of Analog Communication Systems.

Generation and detection of AM and FM

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UNIT II DATA AND PULSE COMMUNICATION

Pulse Communication: Pulse Amplitude Modulation (PAM) – Pulse Time Modulation (PTM) – Pulse code Modulation (PCM) – Comparison of various Pulse Communication System .Data Communication:

History of Data Communication – Standards, Organizations for Data Communication- Data Communication Circuits – Data Communication Codes – Data communication Hardware – serial and parallel interfaces.

UNIT III DIGITAL MODULATION

Amplitude Shift Keying (ASK) – Frequency Shift Keying (FSK)–Phase Shift Keying (PSK) – BPSK –QPSK – Quadrature Amplitude Modulation (QAM) – 8 QAM – 16 QAM – Bandwidth Efficiency–Comparison of various Digital Communication System, Pulse modulation PAM,PPM,PWM,PCM Data communication, Source and Error control coding,

UNIT IV SOURCE AND ERROR CONTROL CODING

Entropy, Source Encoding Theorem, Shannon Fano Coding, Huffman Coding, Mutual Information, Channel Capacity, Error Control Coding, Linear Block Codes, Cyclic Codes – ARQ Techniques Simulation of error control coding schemes.

UNIT V MULTI-USER RADIO COMMUNICATION

Global System for Mobile Communications (GSM) – Code Division Multiple Access (CDMA) – Cellular Concept and Frequency Reuse – Channel Assignment and Handover Techniques – Overview of Multiple Access Schemes – Satellite Communication – Bluetooth.

Simulation of Communication link

TEXT BOOKS
1. Wayne Tomasi, “Advanced Electronic Communication Systems”, 6th Edition, Pearson Education, 2009.
2. B.P.Lathi,“Modern Analog and Digital Communication Systems”, 3rd Edition, Oxford University Press,2007.
REFERENCES
1. Simon Haykin, “Communication Systems”, 4th Edition, John Wiley & Sons, 2004
2. Rappaport T.S, "Wireless Communications: Principles and Practice", 2nd Edition, Pearson Education,2007
3. H.Taub, D L Schilling and G Saha, “Principles of Communication”, 3rd Edition, PearsonEducation, 2007.
4. Blake, “Electronic Communication Systems”, Thomson Delmar Publications, 2002

Laboratory Experiments:

1. Measurement of modulation index of an AM signal.
2. Measurement of output power with varying modulation index an AM signal(for both DSB- & SSB).
3. Measurement of distortion of the demodulated output with varying modulation index of an AM signal (for both DSB-SC & SSB).
4. Measurement of power of different frequency components of a frequency modulated signal & the measurement of the bandwidth.

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5. Design, implementation and study of all the properties of 7-length and 15-length pn sequences using shift register.
6. Study of PAM and demodulation.
7. Study of PCM and demodulation.
8. Study of line coders: polar/unipolar/bipolar NRZ ,RZ and Manchester.
9. Study of delta modulator and demodulator..
10. Study of BPSK modulator and demodulator.
11. Study of ASK modulator and demodulator.
12. Study of QPSK modulator and demodulator

Microprocessors and Microcontrollers Credit 3 (3-0-0)

Overview of Microcomputer systems and their building blocks – Intel 8085 Microprocessor Unit (MPU) Architecture – Interfacing with Memory and I/O Devices

Introduction to 8085: Instruction Set and Assembly Language Programming (ALP), Counters andTime Delays, Stack and Subroutines

Concept of Interrupts and Direct Memory Access

Interfacing with Peripheral Devices – D/A and A/D Converters, Parallel I/O, Timer – Serial I/O and Data Communication

Application / System Level Interfacing Design, Introduction to Single-chip Microcomputer / Intel 8051 Microcontroller Architecture and Programming

Trends in Microprocessor Technology: Introduction to Intel 8086 / 8088 – Arithmetic Coprocessor , Advanced Coprocessor Architecture -286, 486, Pentium - Introduction to RISC Processors.

Keyboard Interface controller-8279

DMA Controller

Text/Reference Books:

1. R. S. Gaonkar, Microprocessor Architecture: Programming and Applications with the 8085/8080A, Penram International Publishing, 2013/2015
2. D. A. Patterson and J H Hennessy, "Computer Organization and Design: The hardware and software interface. Morgan Kaufman Publishers.
3. Douglas Hall, Microprocessors Interfacing, Tata McGraw Hill, 1991.
4. Kenneth J. Ayala, The 8051 Microcontroller, Penram International Publishing, 1996.

Laboratory Experiments:

1. Familiarization with 8085 & 8051 simulator on PC.
2. Study of prewritten programs using basic instruction set (data transfer, Load/Store, Arithmetic, Logical) on the KIT. Assignments based on above
3. Programming using kit and simulator for:
   i) Table look up
   ii) Copying a block of memory
   iii) Shifting a block of memory

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iv) Packing and unpacking of BCD numbers
v) Addition of BCD numbers
vi) Binary to ASCII conversion
vii) String Matching, Multiplication using shift and add method and Booth's Algorithm

4. Program using subroutine calls and IN/OUT instructions using 8255 PPI on the trainer kit e.g. subroutine for delay, reading switch state and glowing LEDs accordingly.
5. Study of the timing diagram of an instruction on an oscilloscope..
6. Interfacing of 8255: Keyboard and Multi-digit Display with multiplexing using 8255
7. Study of 8051 Microcontroller kit and writing programs. Write programs to interface Keyboard, DAC and ADC using the kit.
8. Serial communication between two trainer kits

Computer Organization and Architecture Credit 3(3-0-0)

Concepts Moore's Law, Basic Organization of a Computer and Underlying technology

Computer Performance
CPU time, Amdahl's Law, CPU Performance Equation.

Computer Instructions
Operations and Operands of the hardware, example conversions from C to MIPS.

ALU Design
Realization of basic arithmetic (addition, subtraction) and logical (AND, OR, NOT) operations, Faster Addition using Carry Lookahead.

Computer Arithmetic
Representation of numbers, Addition, Subtraction, Multiplication, Division operations (flowcharts, block level hardware designs).

Processor Design
CPU Design, Datapath Building, Control Unit Design using Hardwired Control and Microprogrammed Control, Overview of Parallel Processing.

Memory Design
Memory Hierarchy, Basics of Cache, Cache Performance, Different Cache Designs - direct mapped, fully associative and set associative caches, virtual memory.

I/O Organization
Basics, Programmed I/O –memory-mapped I/O and I/O mapped I/O.

Text/Reference Books:

1. D. A. Patterson and J. H. Hennessy, "Computer Organization and Design: The Hardware/Software Interface‖, Morgan Kaufman.
2. J. P. Hayes, ―Computer Organization and Architecture‖, McGraw Hill.

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Laboratory Experiments:

1. HDL introduction.
2. Basic digital logic base programming with HDL
3. 8-bit Addition, Multiplication, Division
4. 8-bit Register design
5. Memory unit design and perform memory operations.
6. 8-bit simple ALU design
7. 8-bit simple CPU design
8. Interfacing of CPU and Memory.

Database Management System: Credit 3(3-0-0)

Module 1 Database system architecture: Data Abstraction, Data Independence, Data Definition Language (DDL), Data Manipulation Language (DML). Data models: Entity-relationship model, network model, relational and object oriented data models, integrity constraints, data manipulation operations.

Module 2: Relational query languages: Relational algebra, Tuple and domain relational calculus, SQL3, DDL and DML constructs, Open source and Commercial DBMS - MYSQL, ORACLE, DB2, SQL server. Relational database design: Domain and data dependency, Armstrong's axioms, Normal forms, Dependency preservation, Lossless design. Query processing and optimization: Evaluation of relational algebra expressions, Query equivalence, Join strategies, Query optimization algorithms.

Module 3: Storage strategies: Indices, B-trees, hashing.

Module 4: Transaction processing: Concurrency control, ACID property, Serializability of scheduling, Locking and timestamp based schedulers, Multi-version and optimistic Concurrency Control schemes, Database recovery.

Module 5: Database Security: Authentication, Authorization and access control, DAC, MAC and RBAC models, Intrusion detection, SQL injection.

Module 6: Advanced topics: Object oriented and object relational databases, Logical databases, Web databases, Distributed databases, Data warehousing and data mining.

Text books:
1. “Database System Concepts”, 6th Edition by Abraham Silberschatz, Henry F. Korth, S. Sudarshan, McGraw-Hill.

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SEMESTER: V

Sl No.	Course Name	Course Type	Course Code	Credit	Type		
					L	T	P
1	Digital Signal Processing	MPC		3	3	0	0
2	Electromagnetic Theory	MPC		3	3	0	0
3	Control System	MPC		3	3	0	0
4	Introduction to IC Fabrication Technology	MPC		3	0	0	0
5	VLSI Design	MPC		3	3	0	0
6	Slot for minor	Minor/OE		4	3	0	2
7	Digital Signal Processing Lab	MPC		1	0	0	2
8	VLSI Design Lab	MPC		1	0	0	2
9	Minor Project/Mentor Seminar	Voc NM7		2	0	0	4
10	Vocational-Soft Skill Development-V	Voc NM8		1	0	0	2
	Total (Major-17, Minor-4, Voc-3)						
				24	**30 hours/ week**		

Digital Signal Processing: Credit 3(3-0-0)
Discrete time signals: Sequences; representation of signals on orthogonal basis; Sampling and reconstruction of signals; Discrete systems attributes, Z-Transform, Analysis of LSI systems, frequency Analysis, Inverse Systems, Discrete Fourier Transform (DFT),Fast Fourier Transform Algorithm, Implementation of Discrete Time Systems

Design of FIR Digital filters: Window method, Park-McClellan's method. Design of IIR Digital Filters: Butterworth, Chebyshev and Elliptic Approximations; Lowpass, Bandpass, Bandstop and High pass filters.

Effect of finite register length in FIR filter design.Parametric and non-parametric spectral estimation. Introduction to multirate signal processing. Application of DSP.

Text/Reference Books:
1. S.K.Mitra, Digital Signal Processing: A computer based approach.TMH
2. A.V. Oppenheim and Schafer, Discrete Time Signal Processing, Prentice Hall, 1989.
3. John G. Proakis and D.G. Manolakis, Digital Signal Processing: Principles, Algorithms And Applications, Prentice Hall, 1997.
4. L.R. Rabiner and B. Gold, Theory and Application of Digital Signal Processing, Prentice Hall,
5. J.R. Johnson, Introduction to Digital Signal Processing, Prentice Hall, 1992. 6. D.J.DeFatta, J. G. Lucas andW.S.Hodgkiss, Digital Signal Processing, John Wiley& Sons, 1988.

Laboratory Experiments:

Simulation Laboratory using standard Simulator:
1. Sampled sinusoidal signal, various sequences and different arithmetic operations.
2. Convolution of two sequences using graphical methods and using commands verification of the properties of convolution.

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3. Z-transform of various sequences - verification of the properties of Z-transform.
4. Twiddle factors - verification of the properties.
5. DFTs / IDFTs using matrix multiplication and also using commands.
6. Circular convolution of two sequences using graphical methods and using commands, differentiation between linear and circular convolutions.
7. Verifications of the different algorithms associated with filtering of long data sequences and Overlap -add and Overlap-save methods.
8. Butterworth filter design with a different set of parameters.
9. FIR filter design using rectangular, Hamming and Blackman windows.

Electromagnetic theory: Credit 3(3-0-0)

Maxwell's Equations- Basics of Vectors, Vector calculus, Basic laws of Electromagnetics, Maxwell's Equations, Boundary conditions at Media Interface.

Transmission Lines- Equations of Voltage and Current on TX line, Propagationconstant and characteristic impedance, and reflection coefficient and VSWR, Impedance Transformation on Loss-less and Low loss Transmission line, Power transfer on TX line, Smith Chart, Admittance Smith Chart, Applications of transmission lines: Impedance Matching, use transmission line sections as circuit elements.

Uniform Plane Wave- Uniform plane wave, Propagation of wave, Wave polarization, Poincare's Sphere, Wave propagation in conducting medium, phase and group velocity, Power flow and Poynting vector, Surface current and power loss in a conductor

Plane Waves at a Media Interface- Plane wave in arbitrary direction, Reflection and refraction at dielectric interface, Total internal reflection, wave polarization at media interface, Reflection from a conducting boundary.

Wave propagation in parallel plane waveguide, Analysis of waveguide general approach, Rectangular waveguide, Modal propagation in rectangular waveguide, Surface currents on the waveguide walls, Field visualization, Attenuation in waveguide.

Introduction to EMI and EMC, Intra and inter system EMI, Elements of Interference, Sources and Victims of EMI, Conducted and Radiated EMI emission and susceptibility, Radiation hazards to humans, Various issues of EMC, EMC Testing categories, EMC Engineering Application.

Radiation: Solution for potential function, Radiation from the Hertz dipole, Power radiated by hertz dipole, Radiation Parameters of antenna, receiving antenna, Monopole and Dipole antenna,

Text/Reference Books:

1. R.K. Shevgaonkar, Electromagnetic Waves, Tata McGraw Hill India, 2005
2. E.C. Jordan & K.G. Balmain, Electromagnetic waves & Radiating Systems, Prentice Hall, India
3. Narayana Rao, N: Engineering Electromagnetics, 3rd ed., Prentice Hall, 1997.
4. David Cheng, Electromagnetics, Prentice Hall
5. Clayton Paul, "Introduction to Electromagnetic Compatibility", Wiley Interscience, 2006.

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Control System: Credit 3(3-0-0)

Introduction to control problems- Industrial Control examples. Transfer function. System with dead-time. System response. Control hardware and their models: potentiometers, synchros, LVDT, dc and ac servomotors, tacho-generators, electro hydraulic valves, hydraulic servo motors, electro pneumatic valves, pneumatic actuators. Closed-loop systems. Block diagram and signal flow graph analysis.

Feedback control systems- Stability, steady-state accuracy,transient accuracy, disturbance rejection, insensitivity and robustness. proportional, integral and derivative systems. Feedforward and multi-loop control configurations, stability concept, relative stability, Routh stability criterion.

Time response of second-order systems, steady-state errors and error constants. Performance specifications in time-domain. Root locus method of design. Lead and lag compensation.

Frequency-response analysis- Polar plots, Bode plot, stability in frequency domain, Nyquist plots. Nyquist stability criterion. Performance specifications in frequency-domain. Frequency domain methods of design, Compensation & their realization in time & frequency domain. Lead and Lag compensation. Op-amp based and digital implementation of compensators. Tuning of process controllers. State variable formulation and solution.

State variable Analysis- Concepts of state, state variable, state model, state models for linear continuous time functions, diagonalization of transfer function, solution of state equations, concept of controllability & observability.

Introduction to Optimal control & Nonlinear control, Optimal Control problem, Regulator problem, Output regulator, treking problem. Nonlinear system – Basic concept & analysis.

Text/Reference Books:

1. Gopal. M., “Control Systems: Principles and Design”, Tata McGraw-Hill, 1997.
2. Kuo, B.C., “Automatic Control System”, Prentice Hall, sixth edition, 1993.
3. Ogata, K., “Modern Control Engineering”, Prentice Hall, second edition, 1991.

Introduction to IC Fabrication Technology: Credit (3-0-0)

UNIT I –

CRYSTAL GROWTH

Introduction to Semiconductor Manufacturing and fabrication, Clean Room types and Standards, Physics of Crystal growth, wafer fabrication and basic properties of silicon wafers.

UNIT II –

LITHOGRAPHY AND ETCHING

The Photolithographic Process, Photomask Fabrication, Comparison between positive and negative photoresists, Exposure Systems, Characteristics of Exposure Systems, E-beam Lithography, X- ray lithography. Feature Size control, wet chemical etching, isotropic and anisotropic Etch mechanism, dry etching, Plasma Etching techniques and Equipments.

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UNIT III- Thermal Oxidation

The Oxidation Process, Modeling Oxidation, Masking Properties of Silicon Dioxide, Technology of Oxidation, Si-SiO2 Interface.

UNIT IV - DIFFUSION, ION IMPLANTATION

The Diffusion Process , Mathematical Model for Diffusion, Constant- ,The Diffusion Coefficient , Successive Diffusions, Diffusion Systems, Implantation Technology, Mathematical Model for Ion Implantation, Selective Implantation, Channeling, Lattice Damage and Annealing, Shallow Implantation.

UNIT V - Contacts, packaging and yield

Metal Interconnections and Contact Technology, Silicides and Multilayer-Contact Technology, Copper Interconnects and Damascene Processes, Wafer Thinning and Die Separation, Die Attachment, Wire Bonding, Packages, Yield

UNIT VI- VLSI PROCESS INTEGRATION

NMOS IC Technology – CMOS IC Technology – MOS Memory IC technology - Bipolar IC Technology – IC Fabrication.

Text/Reference books:

1. S.M.Sze, “VLSI Technology”, McGraw Hill, 2nd Edition. 2008.

2. James D. Plummer, Michael D. Deal, Peter B.Griffin, “Silicon VLSI Technology: fundamentals practice and Modeling”, Prentice Hall India, 2009.

3. S.A. Campbell, The science and engineering of microelectronics fabrication, Oxford University Press, UK, Second Edition, 2012.

4. Wai Kai Chen, “VLSI Technology” CRC press, 2003.

VLSI Design Credit 3(3-0-0)

IC DESIGN : Introduction Discrete and Integrated Circuit: TTL, DTL, IIL, ECL, MOS and CMOS IC. Introduction to analog design, symbols, MOSFET as switch, derivation of I/V characteristics, second order effects, MOS device layout, MOS small signal model, SPICE simulation models. Single-stage amplifiers, different common-source stages, source follower, common-gate stage, cascode stage. Differential amplifiers, active diode resistors and switched capacitor resistors; current sinks and sources, current mirrors and amplifiers, voltage and current references, cascade amplifiers; operational amplifiers; design of twostate and cascade op Amp. Analogue circuits: comparators, switched capacitor amplifiers, integrators, filters; DAC and ADC circuits. MOS inverters: definition and properties, MOS and CMOS inverter, VTC characteristics, BI CMOS circuit technique BI CMOS device and technology.

VHDL and VERILOG: Basic language elements: data objects, classes and data types, operators, overloading, logical operators, VHDL representation of digital design entity, entity and architectural declarations, introduction to behavioral, dataflow and structural models.

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FPGA Design and Architecture: Introduction and fundamental concepts, the origin of FPGA, FPGA architecture and design Flows.

Text/Reference Books:

1. S.M Kang and Y.Leblebici., CMOS Digital Integrated Circuits.
2. R.L.Geiger, VLSI Design Techniques for Analog and Digital Circuits,
3. Wayne Wolf , Modern VLSI Design systems on Silicon
4. J. M. Rabaey , Digital Integrated Circuits

SEMESTER: VI

Sl No.	Course Name	Course Type	Course Code	Credit	Type		
					L	T	P
1	Embedded Systems	MPC		3	3	0	0
2	VLSI Verification and Testing	MPC		3	3	0	0
3	Semiconductor Material Synthesis and Characterization	MPC		3	3	0	0
4	Analog IC Design	MPE		3	3	0	0
	Semiconductor Device Modeling	MPE					
	Introduction to MEMS	MPE					
5	Slot for minor	Minor/OE		4	3	1	0
6	Embedded System Lab	MPC		1	0	0	2
7	VLSI Verification and Testing Lab	MPC		1	0	0	2
8	Minor Project/Mentor Seminar	Voc NM9		2	0	0	4
9	Vocational-Soft Skill Development-VI	Voc NM10		1	0	0	2
	Total (Major-14, Minor-4, Voc-3)						
	Total						

Embedded Systems Credit 3 (3-0-0)

Introduction to Embedded Systems (ES), Definition, Difference between general purpose computing system and embedded system; classification of embedded systems - RISC and CISC Processors, Characteristics and Quality Attributes of Embedded Systems, Concepts of Embedded System Design, Examples of Embedded Systems Embedded Microcontroller Cores /

Designing with 8-bit Microcontroller: Architecture, Addressing modes and Instruction Set of Intel 8051 Microcontroller

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Introduction to other Embedded Processors: ASIC, Digital Signal Processors, Field Programmable Gate Array, ARM - Choice of Embedded Hardware Platform Interfacing Standards – Real Time System Design Example RTOS - Hardware Software co-design, ASIC Design, Semicustomed ICs including FPGA,

Microcontroller Design, Cloud and IOT

Text / Reference Books:

1. Introduction to Embedded Systems, Shibu K V, McGraw Hill, New Delhi (2/e)
2. Embedded System Design, SantanuChattopadhyay, PHI Learning (2/e)
3. K.J. Ayala, "The 8051 Microcontroller: Architecture, Programming, and Applications", Penram Intl, 1996.
4. J.W. Valvano, "Embedded Microcomputer System: Real Time Interfacing", Brooks/Cole, 2000.
5. Jack Ganssle, "The Art of Designing Embedded Systems", Newness, 1999

VLSI Verification and Testing Credit 3 (3-0-0)

Module I: Introduction
Introduction to Digital VLSI Design Flow, High Level Design Representation, Transformations for High Level Synthesis
Module II: Scheduling, Allocation and Binding: Introduction to HLS:Scheduling, Allocation and Binding Problem, Scheduling Algorithms
Lecture IV:Binding and Allocation Algorithms
Module III: Logic Optimization and Synthesis, Two level Boolean Logic Synthesis, Heuristic Minimization of Two-Level Circuits, Finite State Machine Synthesis, Multilevel Implementation
Module IV: Verification: Binary Decision Diagram: Binary Decision Diagram: Introduction and construction, Ordered Binary Decision Diagram, Operations on Ordered Binary Decision Diagram, Ordered Binary Decision Diagram for Sequential Circuits
Module - V: Temporal Logic: Introduction and Basic Operations on Temporal Logic, Syntax and Semantics of CLT, Equivalence between CTLFormulas
Module-VI: Model Checking: Verification Techniques, Model Checking Algorithm, Symbolic Model Checking
Module VII: Introduction to Digital Testing:Introduction to Digital VLSI Testing, Functional and Structural Testing, Fault Equivalence
Module VIII: Fault Simulation and Testability Measures: Fault Simulation, Testability Measures (SCOAP)
Module IX: Combinational Circuit Test Pattern Generation: Introduction to Automatic Test Pattern Generation (ATPG) and ATPG Algebras, D-Algorithm
Module X: Sequential Circuit Testing and Scan Chains: ATPG for Synchronous Sequential Circuits, Scan Chain based Sequential Circuit Testing
Module XI: Built in Self test (BIST): Built in Self Test, Memory Testing

Text Books:

1. D. D. Gajski, N. D. Dutt, A.C.-H. Wu and S.Y.-L. Lin, HighLevel Synthesis: Introduction to Chip and System Design, Springer, 1st edition, 1992.
2. S. Palnitkar, Verilog HDL:A Guide to Digital Design and Synthesis, Prentice Hall, 2nd edition, 2003.
3. G. De Micheli.Synthesis and optimization of digital circuits, 1st edition, 1994.
4. M. Huth and M. Ryan, Logic in Computer Science modeling and reasoning about systems, Cambridge University Press, 2nd Edition, 2004
5. Bushnell and Agrawal,Essentials of Electronic Testing for Digital, Memory & Mixed-Signal Circuits,Kluwer Academic Publishers, 2000

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Semiconductor Material Synthesis and Characterization: Credit 3 (3-0-0)

Introduction to semiconductor growth technology, sol-gel technique, VLS technique, VS technique, CVD, atomic layer deposition
Epitaxial growth: molecular beam epitaxy, MOVPE, LPE

Electron microscopy: SEM, FESEM, TEM

Structural Characterization: AFM, XRD, SIMS, FIB

Optical Characterization: optical absorption, photoluminescence, cathodoluminescence, photocurrent

Text Books:

1. Plummer, Silicon VLSI Technology
2. S. M. Sze, Kwok K Ng, Physics of Semiconductor Devices
3. Pallab Bhattacharya, Semiconductor Optoelectronic Devices

Analog IC Design: Credit 3 (3-0-0)
Course introduction.
Negative feedback systems and stability: Negative feedback amplifier using an integrator; Frequency and time domain behavior; Loop gain and its implications; Negative feedback amplifier realization; Finite DC gain; Increasing DC gain;Effect of multiple poles; Negative feedback systems with multiple poles and zeros in the forward path;Stability analysis using Nyquist criterion; Nyquist criterion; Loop gain-Bode plot and time domain interpretation; Significance of 60 degree phase margin.

Opamp at the block level; Frequency compensation; Concept of the opamp for realizing negative feedback circuits; Realizing a multi stage opamp-frequency compensation-miller opamp; Realizing a multi stage opamp; feedforward compensated opamp; Opamp as a general block; unity gain compensation; non idealities swing limits, slew rate, offset; dc negative feedback around opamps.

Opamp amplifiers; Amplifiers using Miller compensated opamp; Effect of input capacitance; gain bandwidth product; Transimpedance amplifier; lead-lag compensation; Inverting and noninverting amplifiers-CMRR and its importance.
Components available on an IC: IC components and their models; Mismatch; Layout considerations

Noise in resistors and MOS transistors: Noise models; Noise calculations; Noise scaling

Review of basic amplifier stages: Body effect in basic amplifier stages; Frequency response of a common source amplifier
Single ended opamp design: Realizing a single stage opamp-diff pair; small signal ac analysis;Single stage opamp-mismatch and noise;Single stage opamp-telescopic cascode; Replica biasing a cascode;Single stage opamp-folded cascode; Two stage miller compensated opamp; Three stage opamp; CMRR of an opamp and opamp circuits Fully differential opamp design: Fully differential opamps; Differential and common mode half circuits; common mode feedback; Fully differential miller compensated opamp-common mode feedback loop and its stability; Fully differential single stage opamp; Fully differential telescopic cascode opamp; Fully differential feedforward compensated opamp
Phase locked loop: Frequency multiplier-Phase locked loop; Lock range limitations; type II loop; Jitter & Phase noise; Continuous time approximation; PLLtransfer functions; Reference feedthrough spurs; LC oscillators
Reference voltage and current generators: Bandgap reference; Bandgap reference; Constant current and constant gm bias generators
Low dropout regulators: Low dropout regulators; Basic requirements and constraints

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Continuous time filters: Active RC filters using integrators
Switched capacitor filters: Switched capacitor filters using the bilinear transformation
Circuit simulators: Basic analyses; Simulating loop gain

Text Books:
1. Behzad Razavi, Design ofAnalog CMOS Integrated Circuits, McGraw-Hill, August 2000.

Semiconductor Device Modelling: Credit 3 (3-0-0)

Introduction -: Si-Based Nanoelectronics and Device Scaling, Nanoscale and Heterostructure Devices, Crystal structure- Unit cell and Miller Indices Reciprocal Space, Doping, Band Structure, Effective Mass Density of states, Electron Mobility, Semiconductor Statistics- Fermi-Dirac function and carrier concentration calculation p-n junction under equilibrium, derivation of I-V relation, Minority carrier diffusion equation, Non-idealities in the p-n junction diode (Breakdown and Generation-Recombination currents), Transistor configurations

BJT- I-V relation and gain, Ebers-Moll model, Non-idealities in BJT, Gummel Poon Model, HBT, BJT Transient and small signal behavior, Metal-Semiconductor contact (Schottky Barrier/Diode, Ohmic Contacts) and capacitance characteristics, Thermionic emission current flow and fermi-level pinning

Field Effect Transistors (JFET, MESFET, HEMT), MOS Band diagram and C-V characteristics, Threshold voltage and Interface charges, MOSFET I-V, gradual channel approximation and frequency response, non-idealities and CMOS
Semiclassical Transport Theory -: Distribution Function, Boltzmann Transport Equation (BTE), Relaxation-Time Approximation (RTA), Scattering and Mobility.

Drift-Diffusion (DD) model-1 -: Drift-Diffusion Model Derivation and dielectric relaxation time, Taylor series expansion and Finite Difference method, Normalization, Scaling and Linearization of Poisson's Equation and Scharfetter–Gummel Discretization of the Continuity Equation

Drift-Diffusion (DD) model-2 -: Generation and Recombination models, Derivation of SRH model, Boundary conditions, Gummel's Iteration Method and Newton's Method, Drift-Diffusion Application example

Hydrodynamic Modelling -: As extension of DD model, Carrier Balance, Energy balance and momentum balance Equations, Direct solution scheme through Monte Carlo simulations

Quantum Transport models -: Tunneling, Schrodinger equation and free particle, potential step, potential barrier, Transfer Matrix Approach, Quantum Mechanical corrections to standard approach.

Examples through commercial device simulation tools, Models for DD, Hydrodynamic simulations, Mobility and G-R models, Selected Examples

Text Books:
1. B. G. Streetman, and S. K. Banerjee, "Solid State Electronic Devices," 7th edition, Pearson,2014.
2. S. M. Sze and K. N. Kwok, "Physics of Semiconductor Devices," 3rd edition, John Wiley&Sons, 2006.
3. D Vasileska, SM. Goodnick, G Klimeck, "Computational Electronics: Semiclassical and Quantum Device Modeling and Simulation," CRC Press 2010.
4. Selberherr Siegfried, "Analysis and Simulation of Semiconductor Devices", 1984

Introduction to MEMS: Credit 3 (3-0-0)

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Introduction, Fundamentals: Material properties – electrical properties, thermal properties, mechanical properties, surface chemistry

Micro-fabrication: materials, clean-rooms, Deposition methods, Photo-lithography, Etching, Advanced tools, LIGA/electroplating, fabs, Self-assembly

Applications: MEMS sensors and actuators, accelerometers, Optical switches, micro-fluidics, micro-channels, micro-pumps, Cells and chips

Neural Implants

Text Books

May, Sze: Fundamentals of Semiconductor Fabrication
Sze: SC Sensors
Madou: Fundamentals of Microfabrication
S. Senturia, Microsystem Design, Kluwer 2000
G. Kovacs, Micromachined Transducers Sourcebook, McGraw-Hill 1998

SEMESTER: VII

Sl No.	Course Name	Course Type	Course Code	Credit	Type		
					L	T	P
1	Law for Engineers	VAC		2	3	0	0
2	VLSI Design Automation	MPC		3	3	0	0
3	Low Power VLSI	MPE		3	3	0	0
	RF Microelectronics						
	Digital Image Processing						
	Mixed Signal Design						
4	Slot for minor	Minor/OE		4	3	0	2
5	VLSI Design Automation Lab	MPC		1	0	0	2
6	Internship	Internship		4	0	0	0
7	Project I/Design of VLSI subsystems	Project		4	0	0	8
	Total (Major-7, Minor-4, VAC-2)						
	Total			**21**	**24 Hr/week**		

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Law for Engineers: 2(2-0-0)

Module1

Introduction and Basic Information about Indian Constitution: Meaning of the constitution law and constitutionalism, Historical Background of the Constituent Assembly, Government of India Act of 1935 and Indian Independence Act of 1947,Enforcement of the Constitution, Indian Constitution and its Salient Features, The Preamble of the Constitution, Fundamental Rights, Fundamental Duties, Directive Principles of State Policy, Parliamentary System, Federal System, Centre-State Relations, Amendment of the Constitutional Powers and Procedure, The historical perspectives of the constitutional amendments in India, Emergency Provisions: National Emergency, President Rule, Financial Emergency, and Local Self Government – Constitutional Scheme in India.

Module 2

Union Executive and State Executive: Powers of Indian Parliament Functions of Rajya Sabha, Functions of Lok Sabha, Powers and Functions of the President, Comparison of powers of Indian President with the United States, Powers and Functions of the Prime Minister, Judiciary – The Independence of the Supreme Court, Appointment of Judges, Judicial Review, Public Interest Litigation, Judicial Activism, LokPal, Lok Ayukta, The Lokpal and Lok ayuktas Act 2013, State Executives – Powers and Functions of the Governor, Powers and Functions of the Chief Minister, Functions of State Cabinet, Functions of State Legislature, Functions of High Court and Subordinate Courts.

Module 3

Introduction and Basic Information about Legal System: The Legal System: Sources of Law and the Court Structure: Enacted law -Acts of Parliament are of primary legislation, Common Law or Case law, Principles taken from decisions of judges constitute binding legal rules. The Court System in India and Foreign Courtiers (District Court, District Consumer Forum, Tribunals, High Courts, Supreme ourt). Arbitration: As an alternative to resolving disputes in the normal courts, parties who are in dispute can agree that this will instead be referred to arbitration. Contract law, Tort, Law at workplace.

Module 4

Intellectual Property Laws and Regulation to Information: Intellectual Property Laws- Introduction, Legal Aspects of Patents, Filing of Patent Applications, Rights from Patents, Infringement of Patents, Copyright and its Ownership, Infringement of Copyright, Civil Remedies for Infringement, Regulation to Information- Introduction, Right to Information Act, 2005, Information Technology Act, 2000, Electronic Governance, Secure Electronic Records and Digital Signatures, Digital Signature Certificates, Cyber Regulations Appellate Tribunal, Offences, Limitations of the Information Technology Act.

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Module 5

Business Organizations and E-Governance: Sole Traders, Partnerships: Companies: The Company's Act: Introduction, Formation of a Company, Memorandum of Association, Articles of Association, Prospectus, Shares, Directors, General Meetings and Proceedings, Auditor, Winding up. E-Governance and role of engineers in E-Governance, Need for reformed engineering serving at the Union and State level, Role of I.T. professionals in Judiciary, Problem of Alienation and Secessionism in few states creating hurdles in Industrial development.

Reference Books:

- Brij Kishore Sharma: Introduction to the Indian Constitution, PHI, New Delhi, latest edition.
- Granville Austin: The Indian Constitution: Cornerstone of a Nation. 1966, Oxford Clarendon Press.
- Subhash C. Kashyap: Our Constitution: An Introduction to India's Constitution and constitutional Law, NBT, 2018.
- PM Bakshi: The Constitution of India, Latest Edition, Universal Law Publishing.
- V.K. Ahuja: Law Relating to Intellectual Property Rights (2007)
- Suresh T. Viswanathan: The Indian Cyber Laws, Bharat Law House, New Delhi-88
- P. Narayan: Intellectual Property Law, Eastern Law House, New Delhi
- Prabudh Ganguli: Gearing up for Patents: The Indian Scenario, Orient Longman.
- BL Wadehra: Patents, Trademarks, Designs and Geological Indications.Universal Law Publishing - LexisNexis.
- Intellectual Property Rights: Law and Practice, Module III by ICSI (only relevant sections)

VLSI Design Automation: Credit 3 (3-0-0)

Introduction to Design Methodologies: Design Automation tools, Algorithmic Graph Theory, Computational Complexity, Tractable and Intractable Problems Layout: Compaction, Placement, Floor planning and Routing Problems, Concepts and Algorithms Modeling: Gate Level Modeling and Simulation, Switch level modeling and simulation, Basic issues and Terminology, Binary – Decision diagram, Two – Level Logic Synthesis. Hardware Models: Internal representation of the input algorithm, Allocation, Assignment and Scheduling, Some Scheduling Algorithms, Some aspects of Assignment problem, High – level Transformations. FPGA technologies: Physical Design cycle for FPGA's partitioning and routing for segmented and staggered models. MCM technologies, MCM physical design cycle, Partitioning, Placement – Chip array based and full custom approaches, Routing –Maze routing, Multiple stage routing, Topologic routing, Integrated Pin – Distribution and routing, routing and programmable MCM's.

TEXT BOOKS

1. S.H.Gerez, "Algorithms for VLSI Design Automation", John Wiley 1999. 2. Naveed Sherwani, "Algorithms for VLSI Physical Design Automation" 3rd edition, Springer International Edition. REFERENCES 1. Hill & Peterson, "Computer

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Aided Logical Design with Emphasis on VLSI" Wiley,1993 2. Wayne Wolf, "Modern VLSI Design: Systems on silicon" Pearson Education Asia, 2nd Edition.

Low Power VLSI: Credit 3 (3-0-0)

Basics of MOS circuits: MOS Transistor structure and device modeling, MOS Inverters, MOS Combinational Circuits - Different Logic Families
Sources of Power dissipation: Dynamic Power Dissipation, Short Circuit Power, Switching Power, Glitching Power, Static Power Dissipation, Degrees of Freedom
Supply Voltage Scaling Approaches: Device feature size scaling, Multi-Vdd Circuits
Architectural level approaches: Parallelism, Pipelining, Voltage scaling using high-level transformations, Dynamic voltage scaling, Power Management
Switched Capacitance Minimization Approaches: Hardware Software Trade-off, Bus Encoding, Two's complement Vs Sign Magnitude Architectural optimization, Clock Gating, Logic styles
Leakage Power minimization Approaches: Variable-threshold-voltage CMOS (VTCMOS) approach, Multi-threshold-voltage CMOS (MTCMOS) approach, Power gating, Transistor stacking, Dual-Vt assignment approach (DTCMOS)
Special Topics: Battery-aware Synthesis, Variation tolerant design, CAD tools for low power synthesis

Text Books:

1. Sung Mo Kang, Yusuf Leblebici, CMOS Digital Integrated Circuits, Tata Mcgraw Hill. 2. Neil H. E. Weste and K. Eshraghian, Principles of CMOS VLSI Design, 2nd Edition, Addison Wesley (Indian reprint). 3. A. Bellamour, and M. I. Elmasri, Low Power VLSI CMOS Circuit Design, Kluwer Academic Press, 1995. 4. Anantha P. Chandrakasan and Robert W. Brodersen, Low Power Digital CMOS Design, Kluwer Academic Publishers, 1995.

Reference 1. Kaushik Roy and Sharat C. Prasad, Low-Power CMOS VLSI Design, Wiley-Interscience, 2000.

RF Microelectronics: Credit 3 (3-0-0)

Introduction of RF and wireless technology, Basic concepts in RF, communication technologies.
Review of MOS device physics and distributed systems
Passive RLC networks and passive IC components
High frequency amplifier design
Noise, LNA design, Mixer design
RF power amplifier design, Oscillators, Phase-locked loops
Frequency SynthesizersPhase noise
RF transceivers architecture and design
Introduction to RF- MEMS technology- an emerging technology for RF passive devices

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Digital Image Processing: Credit 3 (3-0-0)

Image Representation and Modeling :Monochrome and color representation, color ordinate systems Monochrome and Color vision Model, sampling and Quantization – Rectangular and Non rectangular Grid sampling and interlacing. Optimum Lioyd-Max quantizer, Compandor design, Practical limitations.

Image Transforms : Two dimensional Orthogonal Transforms, Basic Image, Kroneeker products and Dimensionality: proportion Algorithm etc. for D F T. Hadamard Haar, Slant, DCT and KL Transforms, SUD techniques Image Enhancement, Point operation, Histogram Modeling, Spatial operations, Transform co-operations, Image RestorationIncrease and Weian Filtering, Filtering using transforms, Least square and constrained least square restoration. Maximum Entropy Restoration.

Image Analysis and Vision : Spatial features extraction, Transform, Features, Edge detection, Boundary detection, region representation, Moment Refresevation, Structures shape, Texture, Scene Matching, Image segmentation and classification techniques.

Image Data Compression :Paxel coding: Entropy coding, Run length coding, Bit plane coding Predictive coding. Delta and DPCM techniques, Transform coding –zonal versus threshold coding. Adaptive transform coding. Vector quantization for compression

Text/Reference Books:

1. Rafale C.Gonzales& R. E. Woods, Digital Image Processing

Mixed Signal Design: Credit 3 (3-0-0)

Course content:

Unit 1

Mixed-Signal design concepts and performance measures. Switched capacitor circuit- principles and

applications in filter design- design of frequency and Q tunable continuous time filters. Comparators-

Characterization - Two stage comparators - open loop comparators.

Unit 2

Sample and hold and trans-linear circuits: 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-hold, trans-linear gain cell, trans-linear multiplier.

Unit 3

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.

Data converter fundamentals - DC and dynamic specifications - quantization noise - Nyquist rate

D/A converters - decoder based converters - binary scaled converters - thermometer code converters

- hybrid converters - Nyquist rate A/D converters - Successive approximation, Flash, interpolating,

Folding, Pipelined, Time-interleaved converters.

Unit 4

Phase-locked loop basics; PLL dynamics; frequency synthesis; all-digital PLLs.

Mismatch Issues in Analog Layouts, Introduction to RF IC Design.

Design of VLSI subsystems I: Credit 4 (4-0-0)

CMOS Transistors and Current model

CMOS Inverter and characteristics

Noise Margin and Delay of Inverter

RC Delay

Delay optimization

Combinatorial Circuit Family

Stick Diagram & Interconnects

Text Books:

1.N. Weste and D. Harris, CMOS VLSI Design A Circuits and Systems Perspective, 4th edition, Pearson.

2. J M Rabaey, A. Chandrakasan, B. Nikolic, Digital Integrated Circuits: A Design Perspective.

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SEMESTER: VIII

Sl No.	Course Name	Course Type	Course Code	Credit	Type		
					L	T	P
1	Nanoelectronics Flexible Electronics Semiconductor Optoelectronic Devices	MPE		4	3	1	0
2	Slot for minor	Minor/OE		4	3	1	0
3	Project II/Design of VLSI subsystems II and Biomedical Instrumentation	Project		8	0	0	16
	Total (Major-4, Minor-4, Project-8)						
				16	**24 hrs/ week**		

Nanoelectronics Credit 3 (3-3-0)

UNIT I
Review of the fundamentals of quantum Mechanics – From classical electronics to nanoelectronics; Electronic properties of low dimensional structures – quantum wells, quantum wires, quantum dots.

UNIT II
Charge and spin in single quantum dots, Coulomb blockage, Electron in mesoscopic structure, single electron transfer devices (SETs), Electron spin transistor, Resonant tunnel diodes, Tunnel FETS, Quantum Interference transistors (QUITs), Quantum dot cellular automata (QCAs), Quantum dot array, Quantum computer, Quantum bits (qubits)
UNIT III
Fundamentals of Silicon MOSFET Devices, scaling rules, Gate oxide tunneling and hot electron effects in nano MOSFET, Advanced MOSFETS- Tirigate FETs, FinFETs-CMOS, Nanowire FET, CNT FET, Graphene Transistors, Molecular electronics and Molecular SETs.
UNIT IV
Quantum well lasers, Quantum dot lasers, Quantum wire lasers, LEDs based on nanostructures (wires, tubes, rods and dots), Sensors devices using nanostructured materials.

TEXTS/REFERENCES:
1. Griffiths D J, “Introduction to quantum mechanics”, 2 nd Edition, Pearson Education (2015).
2. Hanson G W, “Fundamentals of Nanoelectronics”, 1 st Edition, Pearson Education (2009).
3. Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices”, Edited by Rainer Waser, 3rd Edition, Wiley-VCH, 2012.
4. SadamichiMaekawa, “Concepts in Spin Electronics”, Oxford Unversity Press, 2006.
5. Banyai. L and Koch. S.W “Semiconductor Quantum Dots”, World Scientific, 1993.
6. K.Goser, P. Glosekotter and J. Dienstuhl, “Nanoelectronics and Nanosystems-From transistors to molecular quantum Devices”, Springer, 2004.
7. Ping Sheng,Zikang Tang, “Nanoscience and Technology: Novel stricture and phenomena”, CRC

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Press; 1st edition (2003).

Flexible Electronics 3(3-0-0)

Introduction to Flexible and Printed Electronics: Evolution of Flexible Electronics, review of cutting-edge research on electronics that can be flexible, plastic, stretchable, conformable or printed. Electronic materials, components, and systems, applications for IoT.
Materials, Processing, and Manufacturing: Various semiconductors, dielectric, and conducting materials, Organic semiconductors, from chemical bonds to bands, Charge injection and transport, Examples of printable functional materials, Thin-film Deposition and Processing Methods for Flexible Devices, Solution-based Patterning Processes; Ink-jet printing, gravure, and other processes, surface energy effects, multilayer patterning.
Flexible Thin-Film Transistors and Circuits: Thin-Film Transistor; Device structure and performance, Electrical characteristics, parameter extraction, characterization methods for rigid and flexible devices, electrical stability, printed transistors; organic/polymer, metal-oxide, electrolyte gated, Case studies; sub micrometer OTFTs and gravure printed OTFTs, From transistors to circuits.
Circuits on flexible and non-silicon substrates, Contacts, and Interfaces to Organic and Inorganic Electronic Devices: Schottky contacts, defects, carrier recombination, the effect of applied mechanical strain.
Other Flexible Devices and System Integration: Organic Light Emitting Diodes, Organic Solar Cells, thin flexible OLED displays, OLED lighting, smart wallpaper, sensors, logic, and memory, RFID tags, Latest applications of printed electronics, Encapsulation, Roll to roll printing processes, Integration Issues, and Designs for the Future.
Text/Reference Books:
1. G. Nisato, D. Lupo, S. Ganz (Editors) (2016), Organic and Printed Electronics: Fundamentals and Applications, CRC Press.
2. M. M. Hussain and N. El-Atab, Handbook of Flexible and Stretchable Electronics, CRC Press, 2020.
3. Sabrie Soloman, 3D Bioprinting Revolution, Khanna Publishing House, 2020.
4. Large Area and Flexible Electronics, Mario Caironi & Yong-Young Noh (Editors (2015), WILEY-VCH.
5. Wong, William S., and Alberto Salleo, (Eds.) (2009) Flexible electronics: materials and applications. Vol. 11. Springer
6. Recent Journal Papers form Flexible and Printed Electronics, IOP, and Organic Electronics, Elsevier.

Semiconductor Optoelectronic Devices Cr 3 (3-0-0)

Module 1: Review of Semiconductor Device Physics: Energy bands in solids, the E-k diagram, density of states, Occupation probability, Fermi level and quasi-Fermi levels, p-n junctions, Schottky junction and Ohmic contacts. Semiconductor optoelectronic materials, Bandgap modification, Heterostructures and Quantum Wells.

Module 2: Interaction of photons with electrons and holes in a semiconductor: Rates of emission and absorption, Condition for amplification by stimulated emission, the laser amplifier.

Module 3: Semiconductor Photon Sources: Electroluminescence, Light emitting diode: Device structure, materials and characteristics, Semiconductor Laser: Basic structure, theory and device characteristics; direct current modulation, Quantum-well lasers; DFB-, DBR- and vertical-cavity surface-emitting lasers (VCSEL).

Module 4: Semiconductor Optical Amplifiers & Modulators: Semiconductor optical amplifiers (SOA), SOA characteristics and some applications, Quantum confined Stark Effect and Electro-Absorption Modulators.

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Module 5: Semiconductor Photodetectors: Types of photodetectors, Photoconductors, Single junction under illumination: photon and carrier-loss mechanisms, Noise in photodetection; Photodiodes, PIN diodes and APDs: structure, materials, characteristics, and device performance. Photo-transistors, solar cells, and CCDs. Optoelectronic integrated circuits - OEICs.

References:

1. B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc., 2nd Ed. (2007)

2. P. Bhattacharya, Semiconductor Optoelectronic Devices, Prentice Hall of India (1997)

3. G. Keiser, Optical Fiber Communications, McGraw-Hill Inc., 3rd Ed. (2000)

4. J. M. Senior, Optical Fiber Communication: Principles and Practice, Prentice Hall of India, 2nd Ed.(1994)

Design of VLSI subsystems II: Credit 4 (4-0-0)

Interconnects

Power

Static Power, and CMOS Latch and flip flop design

Static Timing Analysis

Adder subsystem design, and Approximate Computing

Text Books:

1.N. Weste and D. Harris, CMOS VLSI Design A Circuits and Systems Perspective, 4th edition, Pearson.

2. J M Rabaey, A. Chandrakasan, B. Nikolic, Digital Integrated Circuits: A Design Perspective.

Biomedical Instrumentation: Credit 4 (4-0-0)

Unit-I Physiology and transducers
Cell and its structure, Resting and Action Potential, Nervous system: Functional organization of the nervous system, Structure of nervous system, neurons, synapse,transmitters and neural communication, Cardiovascular system, respiratory system, Basic components of a biomedical system, Transducers, selection criteria, Piezo-electric,ultrasonic transducers, Temperature, measurements - Fiber optic temperature sensors.
Unit-II Electro – Physiological measurements
Electrodes: Limb electrodes, floating electrodes, pre-gelled disposable electrodes, Micro,needle and surface electrodes, Amplifiers: Preamplifiers, differential amplifiers,chopper amplifiers, Isolation amplifier. ECG, EEG, EMG, ERG, Lead systems and recording methods, Typical waveforms. Electrical safety in medical environment:shock hazards, leakage current-Instruments for checking safety parameters of biomedical equipment
Unit-III Non-electrical parameter measurements

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Measurement of blood pressure, Cardiac output, Heart rate, Heart soundPulmonaryfunction measurements, spirometer, Photo Plethysmography, Body Plethysmography,Blood Gas analyzers : pH of blood, measurement of blood pCO2, pO2, finger-tipoximeter, ESR, GSR, measurements, Standard HL7

Unit-IV Medical Imaging

Radiographic and fluoroscopic techniques, X rays, Computer tomography,Mammography, MRI, fMRI, Ultrasonography, Endoscopy, Thermography, Different types of biotelemetry systems and patient monitoring

Unit-V Assisting and therapeutic equipments

Pacemakers, Defibrillators, Ventilators, Nerve and muscle stimulators, Diathermy, HeartLung machine, Audio meters, Dialyzers, Lithotripsy

Text Books:

1. R.S.Khandpur, 'Hand Book of Bio-Medical instrumentation', Tata McGrawHill PublishingCoLtd., 2003.
2. Leslie Cromwell, Fred J.Weibell, Erich A.Pfeiffer, 'Bio-Medical InstrumentationandMeasurements', II edition, Pearson Education, 2002 / PHI.
3. J.Webster, 'Medical Instrumentation', John Wiley & Sons, 1995.
4. L.A. Geddes and L.E.Baker, 'Principles of Applied Bio-Medical Instrumentation', JohnWiley&Sons, 1975.