राष्ट्रीय प्रौद्योगिकी संस्थान मिजोरम
NATIONAL INSTITUTE OF TECHNOLOGY MIZORAM
(An Institute of National Importance under Ministry of Education, Govt. of India)
CHALTLANG, AIZAWL, MIZORAM – 796012

Course Structure & Syllabus for B.Tech Programme in Electronics and Communication Engineering (ECE)

BATCH: 2023-24 onwards

VIDE **BoS** dated **09.10.2023, SENATE SNT 21.19** dated **14.03.2023**

सूक्ष्म कणिका एवं संचार अभियांत्रिकी विभाग
Department of Electronics & Communication Engineering

Course Structure & Syllabus for B.Tech Programme in Electronics and Communication Engineering (ECE)

Classification of Credits Points:

1 Hr Lecture (L) per week	**1.0 Credit**	**1 Hr Tutorial (T) per week**	**1.0 Credit**
1 Hr Laboratory (P) per week	**0.5 Credit**	**AUDIT Course**	**NO Credit**

SEMESTER I				
Course Code	**Course Name**	**Category**	**L-T-P**	**Credit**
HUL 1101	Communicative English	DC	2-0-0	2
MAL 1101	Engineering Mathematics I	DC	3-1-0	4
CHL 1101	Engineering Chemistry	DC	3-0-0	3
EEL 1101	Basic Electrical Engineering	DC	3-0-0	3
MEL 1101	Engineering Mechanics	DC	3-0-0	3
EEP 1101	Basic Electrical Engineering Laboratory	DC	0-0-3	1.5
CHP 1101	Engineering Chemistry Laboratory	DC	0-0-3	1.5
MEP 1101	Engineering Mechanics Laboratory	DC	0-0-3	1.5
HUP 1101	Language Laboratory	DC	0-0-2	1
OBE 1101	Outcome Based Education	DC	1-0-0	AUDIT
TOTAL			15-1-11	**20.5**

SEMESTER II				
Course Code	**Course Name**	**Category**	**L-T-P**	**Credit**
ECL 1201	Basic Electronics Engineering	DC	3-0-0	3
HUL 1202	Social Science	DC	2-0-0	2
MAL 1202	Engineering Mathematics II	DC	3-1-0	4
PHL 1201	Engineering Physics	DC	3-0-0	3
CSL 1201	Introduction to Computer Programming	DC	3-0-0	3
MEP 1201	Engineering Drawing	DC	0-0-4	2
CSP 1201	Introduction to Computer Programming Laboratory	DC	0-0-3	1.5
PHP 1201	Physics Laboratory	DC	0-0-3	1.5
MEP 1202	Workshop	DC	0-0-3	1.5
ECA 1201	Extracurricular Activity	DC	0-0-0	AUDIT
TOTAL			14-1-13	**21.5**

SEMESTER III				
Course Code	**Course Name**	**Category**	**L-T-P**	**Credit**
ECL 1301	Solid State Devices	DC	3-0-0	3
ECL 1302	Digital Logic Design	DC	3-0-0	3
ECL 1303	Signals and Systems	DC	3-0-0	3
EEL 1301	Circuit Theory	DC	3-1-0	4
EEL 1303	Electrical and Electronics Measurements	DC	3-0-0	3
CSL 1301	Data Structures	DC	3-0-0	3
ECP 1302	Digital Logic Design Laboratory	DC	0-0-2	1
EEP 1303	Electrical and Electronics Measurement Laboratory	DC	0-0-2	1
CSP 1301	Data Structures Laboratory	DC	0-0-2	1
TOTAL			18-1-6	**22**

SEMESTER IV				
Course Code	**Course Name**	**Category**	**L-T-P**	**Credit**
ECL 1401	Analog Circuits	DC	3-1-0	4
ECL 1402	Analog Communication	DC	3-0-0	3
ECL 1403	Electromagnetic Theory	DC	3-0-0	3
CSL 1401	Computer Organization and Architecture	DC	3-0-0	3
MAL 1404	Probability Theory and Stochastic Processes	DC	3-0-0	3
ECP 1401	Analog Circuits Laboratory	DC	0-0-3	1.5
ECP 1402	Analog Communication Laboratory	DC	0-0-3	1.5
CSP 1401	Computer Organization and Architecture Lab	DC	0-0-3	1.5
TOTAL			15-1-9	**20.5**

SEMESTER V				
Course Code	**Course Name**	**Category**	**L-T-P**	**Credit**
ECL 1501	Digital Signal Processing	DC	3-0-0	3
ECL 1502	Microprocessors and Microcontrollers	DC	3-0-0	3
ECL 1503	Fundamentals of VLSI Design	DC	3-0-0	3
ECL 1504	RF & Microwave Engineering	DC	3-0-0	3
CSL 1501	Computer Networks	DC	3-0-0	3
ECP 1501	Digital Signal Processing Laboratory	DC	0-0-3	1.5
ECP 1502	Microprocessors and Microcontrollers Laboratory	DC	0-0-3	1.5
ECP 1504	RF & Microwave Engineering Laboratory	DC	0-0-2	1
TOTAL			15-0-8	**19**

SEMESTER VI				
Course Code	**Course Name**	**Category**	**L-T-P**	**Credit**
ECL 1601	Digital Communication	DC	3-0-0	3
ECL 1602	Linear Integrated Circuits	DC	3-0-0	3
EEL 1601	Control Systems – I	DC	3-0-0	3
CSL/ECL/ EEL 16XX	Program Elective – I	DE	3-0-0	3
HUL 1601	Macro Economics & Business Environment	DC	3-0-0	AUDIT
ECP 1601	Digital Communication Laboratory	DC	0-0-3	1.5
ECP 1602	Linear Integrated Circuits Laboratory	DC	0-0-3	1.5
ECP 1603	VLSI Design & Modelling Laboratory	DC	0-0-3	1.5
ECD 1601	Industrial Training and Seminar	DC	0-0-2	1
TOTAL			15-0-11	**17.5**

SEMESTER VII				
Course Code	**Course Name**	**Category**	**L-T-P**	**Credit**
ECL/CSL/EEL 17XX	Program Elective – II	DE	3-0-0	3
ECL/CSL/EEL 17XX	Program Elective – III	DE	3-0-0	3
ECL/CSL/EEL 17XX	Program Elective – IV	DE	3-0-0	3
MAL 1701	Operation Research	DC	3-0-0	AUDIT
ECD 1701	Project Phase – I	DC	0-0-10	5
ECD 1702	Seminar	DC	0-0-4	2
TOTAL			12-0-14	**16**

SEMESTER VIII				
Course Code	**Course Name**	**Category**	**L-T-P**	**Credit**
ECL 18XX	Program Elective – V	DE	3-0-0	3
CHL 1801	Environmental Science	DC	2-0-0	PASS/FAIL
CSL/ECL/EEL 1XXX	Open Elective	DE	3-0-0	3
ECD 1801	Project Phase – II	DC	0-0-20	10
ECD 1802	Grand Viva	DC	0-0-4	2
TOTAL			8-0-24	**18**

SEMESTER WISE CREDIT POINT(s)

SEMESTER	I	II	III	IV	V	VI	VII	VIII
CREDIT POINT	20.5	21.5	22	20.5	19	17.5	16	18
TOTAL								155

Structure of UG programme (B.Tech in ECE) and corresponding credit point(s) in the Curriculum

Sl. NO.	TOPIC / RELEVANT AREA	CREDIT POINT
1	Humanities and Social Science including Management	**5**
2	Basic Sciences	**20**
3	Engineering Sciences including Workshop, Drawing, Basics of Electrical/ Mechanical/ Computer etc.	**20**
4	Professional Core Subjects (Departmental Core)	**49.5**
5	Professional Subjects: Subjects relevant to chosen specialization/branch	**37.5**
6	Open Subjects: Electives from other technical and/or emerging subjects	**3**
7	Project Work, Seminar and Internship in Industry or Elsewhere	**20**
8	Mandatory Courses (Environmental Science, Induction Program, Indian Constitution, Essence of Indian Traditional Knowledge)	**PASS/FAIL**
TOTAL		**155**

ELECTIVES

Open Elective(s) [OE]

Sl. No.	Course Code	Course Name
1	ECL 1X06	Information Theory and Coding
2	ECL 1X09	Nanoelectronic Semiconductor Devices
3	ECL 1X11	CAD for VLSI
4	ECL 1X14	Wireless Sensor Networks
5	ECL 1X18	VHDL Modelling

Program Elective(s) [PE I – PE V]

Sl. No.	Course Code	Course Name
1	ECL 1X04	Foundations of MEMS
2	ECL 1X05	Antenna Engineering
3	ECL 1X06	Information Theory and Coding
4	ECL 1X07	Sensors and Instrumentation
5	ECL 1X08	Low power VLSI Design
6	ECL 1X09	Nanoelectronic Semiconductor Devices
7	ECL 1X10	Radar Communication
8	ECL 1X11	CAD for VLSI
9	ECL 1X12	Digital Image Processing
10	ECL 1X13	Satellite Communication
11	ECL 1X14	Wireless Sensor Networks
12	ECL 1X15	Numerical Techniques in Electromagnetics
13	ECL 1X16	Physics of Nanoscale FET
14	ECL 1X17	Semiconductor Process Technology
15	ECL 1X18	VHDL Modelling
16	ECL 1X19	Detection and Estimation Theory
17	ECL 1X20	Wireless Communication
18	ECL 1X21	Semiconductor Materials and Systems
19	ECL 1X22	Optoelectronic Devices
20	CSL 1XXX	Software Engineering
21	CSL 1XXX	Artificial Intelligence
22	CSL 1XXX	Computer Graphics
23	CSL 1XXX	Machine Learning
24	CSL 1XXX	Bioinformatics
25	CSL 1XXX	Optimization Techniques
26	EEL 1XXX	Instrumentation Engineering
27	EEL 1XXX	Power Electronics and Drives
28	EEL 1XXX	Soft Computing
29	EEL 1XXX	Renewable Energy

FIRST SEMESTER

HUL 1101	**Communicative English**
L-T-P: 2-0-0	**Credits: 2**
As per the syllabus prescribed by Dept. of Basic Science & Humanities and Social Science.	

MAL 1101	**Engineering Mathematics I**
L-T-P: 3-1-0	**Credits: 4**
As per the syllabus prescribed by Dept. of Basic Science & Humanities and Social Science.	

CHL 1101	**Engineering Chemistry**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by Dept. of Basic Science & Humanities and Social Science.	

EEL 1101	**Basic Electrical Engineering**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by Dept. of Electrical and Electronics Engineering.	

MEL 1101	**Engineering Mechanics**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by Dept. of Mechanical Engineering.	

EEP 1101	**Basic Electrical Engineering Laboratory**
L-T-P: 0-0-3	**Credits: 1.5**
As per the syllabus of EEL 1101	

CHP 1101	**Engineering Chemistry Laboratory**
L-T-P: 0-0-3	**Credits: 1.5**
As per the syllabus of CHL 1101.	

MEP 1101	**Engineering Mechanics Laboratory**
L-T-P: 0-0-3	**Credits: 1.5**
As per the syllabus of MEL 1101.	

HUP 1101	**Language Laboratory**
L-T-P: 0-0-2	**Credits: 1**
As per the syllabus of HUL 1101.	

OBE 1101	**Outcome Based Education**
L-T-P: 0-0-2	**AUDIT**
As per the syllabus prescribed by Dept. of Basic Science & Humanities and Social Science.	

SECOND SEMESTER

ECL 1201 | **Basic Electronics Engineering** | **Prerequisite: N/A**
L-T-P: 3-0-0 | **Course Outcome** | **Credits: 3**

CO1 Identify semiconductors, and their properties
CO2 Understand essential operation of semiconductor diodes and transistors
CO3 Characterize and analyze various diodes and their applications
CO4 Design simple rectifier, oscillator and amplifier circuits and BJT characteristics
CO5 Understand the fundamentals of digital number system

Syllabus

Physics and Properties of Semiconductors: **Lectures: 08**
Semiconductor, Metals, Insulators, Energy bands, statistics, Fermi level, carrier concentration at thermal equilibrium, carrier transport phenomena, generation and recombination of carriers, basic properties for semiconductor operation.

PN Junction diode: **Lectures: 06**
Physical Description of p-n junction, Poisson's Equation, current flow at a junction, I–V characteristics, Quantitative analysis of p-n diode characteristics, Avalanche and Zener breakdown (zener diode).

Diode applications: **Lectures: 05**
Filter circuit: Passive filters (RC; low pass, high pass filter), Series and shunt diode clippers, clipping at two independent levels, clamping operation, clamping circuit, Basic regulator supply using Zener diode.

Other diodes: **Lectures: 02**
Photodiode, LED, Varactor and PV Cell.

Transistors: **Lectures: 09**
Construction and characteristics of BJT: CB, CE, CC configuration and their input output characteristics. Transistor action and dependence on device structure, Ebers-Moll Model, Coupled-Diode model current-voltage characteristics.

Field effect transistor: **Lectures: 06**
Construction of JFET, pinch-off voltage, volt-ampere characteristics, transfer characteristics, types of MOSFET (enhancement and depletion) construction and characteristics

Amplifiers and oscillators: **Lectures: 04**
Classification of amplifiers, concept of feedback, Characteristics of feedback amplifiers, basics of oscillator, barkhausen criterion, introduction to Op-Amp.

Basic Digital Logic: **Lectures: 02**
Boolean Algebra, Basic Logic Gates, Number System

Text Books:

1. Electronics: Fundamental and Applications, 15th eds by D. Chattopadhyay and P C Rakshit.
2. Electronics Devices and Circuit Theory by R. Boylestad.
3. Principles of Electronics, VK Mehta and Rohit Mehta, S. Chand Publishing, 2022
4. Digital Circuits Vol. I (Combinational Circuits) by Diptiman Ray Chauduri

Reference Books:

1. Electronics Devices and Circuits-II by A.P.Godre & U.A. Bakshi.
2. Electronics Devices and Circuit by G.K. Mithal.
3. Electronic Principles, A. P. Malvino and D. J. Bates, 7th Edn, McGraw-Hill Higher Education, 2007.
4. D.A. Neamen, Semiconductor Physics & Devices, TMH, 2003.

HUL 1202	**Social Science**
L-T-P: 2-0-0	**Credits: 2**
As per the syllabus prescribed by Dept. of Basic Science & Humanities and Social Science.	

MAL 1202	**Engineering Mathematics II**
L-T-P: 3-1-0	**Credits: 4**
As per the syllabus prescribed by Dept. of Basic Science & Humanities and Social Science.	

PHL 1201	**Engineering Physics**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by Dept. of Basic Science & Humanities and Social Science.	

CSL 1201	**Introduction to Computer Programming**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by Dept. of Computer Science Engineering.	

MEP 1201	**Engineering Drawing**
L-T-P: 0-0-4	**Credits: 2**
As per the syllabus prescribed by Dept. of Mechanical Engineering.	

CSP 1201	**Introduction to Computer Programming Laboratory**
L-T-P: 0-0-3	**Credits: 1.5**
As per the syllabus of CSL 1201.	

PHP 1201	**Physics Laboratory**
L-T-P: 0-0-3	**Credits: 1.5**
As per the syllabus of PHL 1201.	

MEP 1202	**Workshop**
L-T-P: 0-0-3	**Credits: 1.5**
As per the syllabus prescribed by Dept. of Mechanical Engineering.	

ECA 1201	**Extracurricular Activity**
L-T-P: 0-0-0	**AUDIT**

THIRD SEMESTER

ECL 1301 **Solid State Devices** **Prerequisite: ECL 1201**

L-T-P: 3-0-0 **Course Outcome** **Credits: 3**

CO1	To understand the physics and properties of Semiconductor
CO2	To understand the working and analyze non-idealities in junction physics
CO3	To understand the working of Bipolar Junction Transistor and non-ideal effects
CO4	To understand the construction and working of Metal Oxide Semiconductor System
CO5	To analyze non-ideal MOSFET physics and MESFETs

Syllabus

Physics and Properties of Semiconductors: **Lectures: 06**

Crystal Structure, Miller Indices and calculations, symmetry, atomic bonding, Energy Bands, k-space diagram, Einstein Relation, Hall effect, optical and thermal properties, continuity equation, tunnelling and high field effects.

P-N Junction: **Lectures: 08**

Thermal Equilibrium Condition, Depletion Region, Depletion and Diffusion Capacitances, Current-Voltage Characteristics, temperature dependence, Capacitance of p-n junction diode (transition & storage), Heterojuntion, 2D electron gas.

Metal-Semiconductor junction: **Lectures: 06**

Equilibrium, idealized metal semiconductor junctions, non-rectifying (Ohmic) contacts, Schottky diodes, Tunnel Diode, PIN diode

Bipolar Junction Transistor: **Lectures: 02**

Overview of BJT working principle, Non-ideal BJTs their effects and analysis.

MOS and MOSFET: **Lectures: 13**

MOS structure, MOS capacitance (Operation with band diagram, threshold voltage, flatband voltage, CV characteristics, diffusion capacitance), Basic operation of Enhancement & Depletion mode MOSFET (saturation mode, transfer characteristics, mobility, electric field), PMOS, NMOS, CMOS inverter

Non-ideal MOSFET & MESFET: **Lectures: 09**

MOSFET nonuniform doping and buried-channels, Moore's Law, Scaling, Non-ideal effects, basics of short channel effects, SOI MOSFET, HEMT, MESFET

Text Books:

1. Semiconductor Physics and Devices, 3ed, An Indian Adaptation, S. M. Sze, M. K. Lee, R. S. Dhar, A. Nair, 2021 Wiley India.
2. Solid State Electronic Devices, Ben G. Streetman & Sanjay Banerjee, 6ed, Pearson, 2005.
3. Semiconductor physics and Devices by Donald A. Neamen, 4th Edition, TMH, 2012.

Reference Books:

1. Semiconductor Devices- Physics and Tech., Nandita Dasgupta & Amitava DasGupta, PHI, 2010.
2. Microelectronics by Jacob Millman& Arvin Grabel, 2nd Edition, TMH, 2004.
3. Semiconductor Optoelectronic Devices by Pallab Bhattacharaya, 2nd Edition, PHI, 2004.

ECL 1302	**Digital Logic Design**	**Prerequisite: ECL 1201**
L-T-P: 3-0-0	**Course Outcome**	**Credits: 3**

CO1 Design and analyze combinational and sequential logic circuits through HDL models
CO2 Optimize combinational and sequential logic circuits
CO3 Understand fault detection techniques for digital logic circuits
CO4 Analyze a memory cell and apply for organizing larger memories

Syllabus

Introduction to Boolean Algebra and Logic Gates: **Lectures: 08**
Signed binary number, Binary arithmetic, Codes – BCD, Gray, Excess-3, Error detection & Correcting code-Hamming code, Logic Gates, Universal gates, Boolean Algebra, Basic theorems & properties of Boolean Algebra, De-Morgan's theorem, Min terms & Max terms, K-map representation, Q-M Method, simplification and realization with logic gates.

Combinational Circuits: **Lectures: 08**
Code Converters, Adders (Half and Full adders, parallel binary adders, look ahead carry adder generator, BCD Adder), Subtractor (Half and Full subtractor), decoders and Encoders, Priority Encoder, Multiplexer and De-multiplexer, Parity generator/checkers.

Sequential Logic: **Lectures: 08**
Latches, Flip-Flops (SR, D, JK, T and Master Slave JK, Edge Triggered), Conversion of Flip-Flops, Glitches, Shift Register (SISO, SIPO, PIPO, PISO, Bidirectional), Counter (ripple and synchronous, Ring and Johnson Counters).

Memory: **Lectures: 04**
Memory concepts, RAM, ROM, PROM, EPROM, UV-EPROM, EEROM, Flash memory, Optical memory.

Programmable Logic Devices: **Lectures: 02**
PAL, PLA, PROM, CPLD.

Introduction to Logic Families: **Lectures: 04**
Standard logic families (RTL, DTL, HTL, TTL, ECL, CMOS).

D/A and A/D: **Lectures: 04**
Sample and Hold Circuits, Digital to Analog converter (Binary weighted resister network & R-2R ladder network), Analog to Digital converter (Flash type, Counter type, Dual Slope & Successive approximation type).

Text Books:

1. Digital Logic and Computer Design, M. Morris Mano, PHI, 2008.
2. Digital design- Principles and Practices, J. F. Wakerly, 4th Edition, Pearson, 2006.
3. Digital Integrated Electronics, Herbert Taub (Author), Donald Schilling (Author)
4. Digital Principles and Applications, Leach, Malvino, Saha

Reference Books:

1. Digital Fundamentals, Thomas L.Floyd, 10th Edition, Pearson, 2011.
2. Digital Principles and Applications, Donald P. Leach, Albert Paul Malvino, 5th ed, TMH, 1995.
3. Switching & Finite Automata Theory, Zovi Kohavi , 2rd Edition , TMH.,2008.
4. Fundamentals of Digital Logic, Anand Kumar, 2nd Edition, PHI, 2008.
5. Fundamentals of Logic Design, Charles H. Roth Jr, 4th Ed, Jaico publishers, 2002.

ECL 1303 **Signals and Systems** **Prerequisite: ECL 1201**
L-T-P: 3-0-0 **Course Outcome** **Credits: 3**

CO1 Continuous time system analysis in both time and frequency domains
CO2 Discrete signals and systems analysis
CO3 Obtain signal-space diagrams
CO4 Understanding random processes
CO5 Application of Laplace transform in signal and system analysis

Syllabus

Continuous Signals: **Lectures: 12**

Classification of signals, signal operations, correlation, signal properties, system properties: linearity, time/shift-invariance, causality, stability; continuous-time linear time invariant (LTI) systems: impulse response and step response; response to an arbitrary input: convolution; system representation using differential equations; Eigen functions of LTI, frequency response and its relation to the impulse response, Hilbert transform; frequency analysis: Fourier series, Fourier transform, power spectral density; Parseval's theorem, signal distortion in transmission, Paley-Wiener criterion for realizable filters.

Discrete Signals: **Lectures: 12**

Discrete signal representation, energy and power signals, signal operations, correlation, signal properties, system properties: linearity, time/shift-invariance, causality, stability; LTI systems: impulse response and step response; response to an arbitrary input: convolution; system representation using difference equations; forced and natural response, Discrete-time-Fourier-series and transform, Parseval's theorem, sampling and reconstruction of signals, Z-transform and its properties, region of convergence.

Elements of Signal Space Analysis: **Lectures: 03**

Orthogonal and orthonormal signals, Geometric representation of signals, Gram-Schmidt orthoganization Technique.

Random Variables and Processes: **Lectures: 05**

Probability, mutually exclusive events, statistical independence, joint probability, random variables: cumulative and probability density functions, average and variance; optimal receiver; useful probability density functions: Gaussian, Rayleigh, Rician, Binomial and Poisson; central limit theorem; random processes: classification, correlation and power spectral density.

Laplace Transform: **Lectures: 04**

Unilateral and bilateral transform, relation between Fourier and Laplace transforms, mapping of s-plane to z-plane, Laplace transform properties, pole-zero, frequency response of pole-zero locations, zero state and zero input responses.

Text Books:

1. Signals and System by Oppenheimer.
2. Principles of Linear Systems and Signals by B.P. Lathi.
3. Principles of Communication Systems by H. Taub & D.L. Schilling

Reference Books:

1. Random Signals and Systems by D.F. Mix.
2. Discrete time signals and systems by N. Ahmed and T. Natarajan
3. Signals and Systems by S. Haykin and B.V. Veen

EEL 1301	**Circuit Theory**	
L-T-P: 3-1-0		**Credits: 4**
As per the syllabus prescribed by Dept. of Electrical and Electronics Engineering.		

EEL 1303	**Electrical and Electronics Measurements**	
L-T-P: 3-0-0		**Credits: 3**
As per the syllabus prescribed by Dept. of Electrical and Electronics Engineering.		

CSL 1301	**Data Structures**	
L-T-P: 3-0-0		**Credits: 3**
As per the syllabus prescribed by Dept. of Computer Science and Engineering.		

EEP 1303	**Electrical and Electronics Measurement Laboratory**	
L-T-P: 0-0-2		**Credits: 1**
As per the syllabus of EEL 1302.		

CSP 1301	**Data Structures Laboratory**	
L-T-P: 0-0-2		**Credits: 1**
As per the syllabus of CSL 1301.		

ECP 1302 Digital Logic Design Laboratory

L-T-P: 0-0-2 Credits: 1

Experiment List mostly using XILINX:

1. Verification of truth-table of different logic gates: To Study and verify Truth Table of different logic gates.
2. Implementation of various logic gates using universal gates: To Implement various logic gates using universal gates.
3. Implementation of XOR & XNOR using universal gates: To Implement XOR & XNOR using universal gates.
4. Implementation of half adder & full adder using universal gates: To Implement half adder & full adder using universal gates.
5. Implementation of half subtractor & full subtractor using universal gates: To Implement half subtractor & full subtractor using universal gates.
6. Implementation of 8x1 MUX using 4x1 MUX and to realize the given Boolean expression: To Implement 8x1 MUX using 4x1 MUX and to realize the given Boolean expression.
7. Design of 4-bit binary-to-gray code converter: To Design a 4-bit binary-to-gray code converter.
8. Design of 4-bit gray-to-binary code converter: To Design a 4-bit gray-to-binary code converter.
9. Design of 4-bit BCD-to-excess-3 code converter: To Design a 4-bit BCD-to-excess-3 code converter.
10. Implementation of half adder & half subtractor using 2-line to 4-line decoder: To Implement a half adder & half subtractor using 2-line to 4-line decoder.
11. Design of T-flip flop using SR flip flop: To Design a T-flip flop using SR flip flop.
12. Design of a clocked flip flop using 3 input NAND gate and verify the truth table: To Design a clocked flip flop using 3 input NAND gate and verify the truth table.
13. Design a 3-bit binary counter using J-K flip flop: To Design a 3-bit binary counter using JK-flip flop.
14. Design of a Ring Counter & Johnson Counter: To Design a Ring Counter & Johnson Counter.
15. Design of Asynchronous counter & Synchronous Counter: To Design an Asynchronous counter & Synchronous Counter.
16. Realization of Shift Registers: To Design and Realize a given Shift Register.
17. Realization of Encoders: To Design and Realize a given Encoder.

FOURTH SEMESTER

ECL 1401 **Analog Circuits** **Prerequisite: ECL 1201**
L-T-P: 3-1-0 **Course Outcome** **Credits: 4**

CO1 Design and analyze multistage amplifiers.
CO2 Apply compensation techniques for stabilizing analog circuits against parameter variations
CO3 Design negative feedback amplifier circuits and oscillators
CO4 Analyze and design solid state power amplifier circuits.
CO5 Analyze and design tuned amplifier circuits.

Syllabus

Bipolar Junction Transistors (BJTs): **Lectures: 12**
Characteristics of BJT; Ebers-Moll equations and large signal models; inverse mode of operation, early effect; BJT as an amplifier and as a switch; DC biasing of BJT amplifier circuits; small signal operations and models; Single state BJT amplifiers – CE, CB and CC amplifiers; high frequency models and frequency response of BJT amplifiers; Basic design in discrete BJT amplifiers; complete design examples; Basic BJT digital logic inverter.

Metal Oxide Semiconductor Field Effect Transistors (MOSFETs): **Lectures: 12**
MOSFET operational Characteristics; PMOS, NMOS and CMOS current voltage characteristics; DC analysis; Constant Current Sources and Sinks; MOSFET as an Amplifier and as a Switch; Biasing on MOS Amplifiers; Small Signal Operation of MOS amplifiers; Common-source, common gate and source Follower Amplifiers; CMOS amplifiers; MOSFET Digital logic inverters; voltage transfer characteristics.

Amplifier Classes: **Lectures: 06**
Classification of amplifiers; Class A, Class B, Class AB Class C – Circuit operation, transfer characteristics, power dissipation, efficiency. Practical BJT and MOS power transistors; thermal resistance; heat sink design.

Feedback Amplifiers and Oscillators: **Lectures: 10**
Basic feedback topologies; Analysis of Series-shunt, series-series, shunt-shunt and shunt-series feedback amplifiers; stability in feedback amplifiers, frequency compensation; principle of sinusoidal oscillators and Barkhausen criterion; Active-RC and Active-LC sinusoidal oscillators; Wien Bridge; Phase-Shift; Quadrature Oscillators; Crystal Oscillators, application in voltage regulation.

Text Books:
1. Millman's Electronic Devices and Circuits, J. Millman, C.C. Halkias, S. Jit, 4Edn, Mc Graw Hill, 2015.
2. Microelectronic Circuits, Adel S. Sedra and Kenneth Carless Smith, 5th Edn, Oxford, 2004.
3. Fundamentals of Microelectronics, Behzad Razavi, 3rd Edn, Wiley, 2021.
4. Electronic Principles Book by Albert Paul Malvino, 1998.

Reference Books:
1. Electronic devices and Circuit Theory, Robert Boylestad, 9th Edition, Pearson Education, 2007.
2. Microelectronics: Analysis and Design, Sundaram Natarajan, TMH, 2006.
3. Electronic Circuits, D.L. Schilting and C. Belove, TMH.
4. The Art of Electronics, Paul Horowitz and Winfield Hill.

ECL 1402 **Analog Communication** **Prerequisite: ECL 1201**
L-T-P: 3-0-0 **Course Outcome** **Credits: 3**

CO1	Compare the performance of AM, FM and PM schemes with reference to SNR
CO2	Understand noise as a random process and its effect on communication receivers
CO3	Evaluate the performance of PCM, DPCM and DM in a digital communication system
CO4	Identify source coding and channel coding schemes for a given communication link

Syllabus

Introduction to Noise: **Lectures: 06**
Thermal noise, shot noise, White noise, Narrow band noise and its representation, signal to noise Ratio (SNR), noise temperature, noise equivalent bandwidth, noise figure, spectral analysis of noise.

AM Generation and Reception: **Lectures: 14**
Introduction, amplitude modulation (AM); different types of AM, AM power calculations generation of AM signals; square law modulator, modulator ad demodulator concepts and designs: DSB-SC, DSB-C, SSB, VSB, basic elements of AM super-heterodyne receiver; RF amplifier characteristics, Noise in AM.

FM Generation and Reception: **Lectures: 12**
Frequency modulation (FM) and phase modulation (PM); spectra of FM signals, narrow band and wide band FM, transmission bandwidth of FM, frequency translation and multiplexing; generation of FM by direct methods. Indirect generation of FM: the Armstrong method. FM receiver direct methods of frequency demodulation; slope detector, Foster Seely or phase discriminator, ratio detector, indirect methods of FM Demodulation: FM detector using PLL. Noise in FM receivers, pre-emphasis and de-emphasis.

Pulse Modulation Transmission and Reception: **Lectures: 04**
Introduction, pulse amplitude modulation (PAM), PAM modulator circuit, demodulation of PAM signals, pulse time modulation (PTM): pulse width modulation (PWM), pulse position modulation (PPM); PPM demodulator.

Text Books:
1. Modern Digital and Analog Communication Systems, B P Lathi, 4th Edition, OUP, 2009.
2. Principle of Communication Systems, Herbert Taub & Donald L. Schilling, TMH.
3. Communication Systems, Simon Haykin, John Wiley and Sons, 5th Edition, 2009.

Reference Books:
1. Electronic Communication, Dennis Roddy, John Coolen, 4th Edition, Pearson, 1997.
2. Communication Systems, A. B. Carlson,5th Edition, TMH/MGH.
3. Principles of communication Engineering, Umesh Sinha.
4. Communication Theory, T. G. Thomas & S Chandrasekhar, TMH, 2005.
5. Communication system engineering, J.G. Proakis and Salehi, 2nd Edition, PHI, 2001.
6. Digital and Analog Communication Systems, Leon W. Couch, 7th Edition, Pearson, 2008.
7. Contemporary Communication Systems using MATLAB and Simulink, J. G. Proakis & Masoud Salehi & Gerhard Bauch, 3rd Edition, Cengage Learning, 2013.

ECL 1403 **Electromagnetic Theory** **Prerequisite: ECL 1201**
L-T-P: 3-0-0 **Course Outcome** **Credits: 3**

CO1	Solve Maxwell's equations using vector calculus in three standard coordinate systems
CO2	Deduce EM wave propagation in free space and in dielectric medium
CO3	Analyze electromagnetic wave propagation in guiding structures under various matching conditions
CO4	Understand the power flow mechanism in guiding structures and in unbounded medium

Syllabus

Review of co-ordinate systems and vector calculus: **Lectures: 03**
Different coordinate systems, line, surface and volume integrals. Gradient, divergence and curl. Divergence theorem and stokes theorem.

Review of Electrostatics: **Lectures: 05**
Coulomb's law, Gauss's law and its applications. the potential functions, equipotential surface, Poisson's and Laplace's equation. Capacitance, electrostatics energy, conductor properties. Uniqueness theorem.

Review of Magneto Statics: **Lectures: 04**
Biot-Savart law, Ampere circuital law, magnetic flux and magnetic flux density. Energy stored in magnetic field. Ampere's force law, Magnetic vector potential.

Maxwell's Equation: **Lectures: 05**
Equation of continuity for time varying field, inconsistency of Ampere circuital law. Concept of displacement current, Maxwell's equation in integral and differential form. Maxwell equation for time harmonic fields, boundary condition, phasor representation.

Electromagnetic waves: **Lectures: 06**
Solution for free space condition, uniform plane waves, Wave propagation in lossless and lossy dielectric media, skin depth, polarization, surface impedance.

Reflections and Refractions of plane waves: **Lectures: 06**
Reflection by a perfect conductor with normal and oblique incidence, reflection & refractions by perfect dielectrics with normal and oblique incidence. Surface impedance.

Poynting vector: **Lectures: 04**
Poynting theorem, instantaneous average and complex poynting vector, power loss in a plane conductor.

Wave propagation modes: **Lectures: 04**
Ground wave propagation, sky wave, surface wave propagation.

Text Books:

1. Element of Electromagnetics, Mathew N. O. Sadiku, 5th Edition, Oxford University, 2010.
2. Electromagnetic waves and Radiating Systems, E. C. Jordan & K. G. Balmain, 2nd Edition, PHI.
3. Electromagnetics Theory, David K Chang, 2nd edition, Addison Wesley Longman, 1999.
4. Engineering Electromagnetics, William Hayt, John Buck, 8th Edition, TMH, 2008.
5. Introduction to Electrodynamics, David Griffith

Reference Books:

1. Introductory course in electromagnetic fields, P.V. Gupta, 2nd Edition, Dhanpetrai Pub., 1975.
2. Fundamental of Electromagnetics, M.A. Wazed Miah, 5th Edition, TMH, 1985.
3. Electromagnetic fields and waves, V. V. Sarvate, Bohem press, 1993.
4. Electromagnetics by B.B. Laud.
5. Electronic and Radio Engineering, Frederick Emmons Terman,4th Edition, TMH, 1955.
6. Electromagnetic waves and radiating system, E.C Jordan & K.G Balmain, 2nd Edition, PHI, 1979.

CSL 1401 Computer Organization and Architecture	
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by Dept. of Computer Science Engineering.	

MAL 1404 Probability Theory and Stochastic Processes	
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by Dept. of Basic Science & Humanities and Social Science.	

ECP 1401 Analog Circuits Laboratory

L-T-P: 0-0-3 **Credits: 1.5**

Experiment List:

1. To identify the various Electronics Instruments and Electronic circuit components.
2. To study the characteristics of Zener diode under forward and reverse bias condition.
3. To study the operation of half-wave Rectifier.
4. To study the operation of Full-wave rectifier.
5. To operation of bridge Rectifier.
6. To plot the transistor characteristic of common-emitter configuration and to find the h-parameter for the same.
7. To plot the transistor characteristic of common-base configuration and to find the h-parameter for the same.
8. To plot the transistor characteristic of common-collector configuration and to find the h-parameter for the same.
9. To observe the clipping waveform in different clipping configurations.
10. To observe the clamping circuits, positive clamping circuit and negative clamping circuit.
11. Study the switching characteristics of transistor: Rise time, Fall time, ON/OFF time & Delay time.
12. To design and implement the fixed-bias amplifier circuit and obtain the waveforms at input and output terminals, the bias resistances, measure the gain & the frequency plot.
13. To design and implement the RC couple amplifier circuit and to find Cut off frequencies, Band width & Mid band gain input/output impedance.
14. To study the following application of op-amp using (741): Voltage follower, inverting amplifier, non-inverting amplifier, variable voltage gain amplifier, Adder & subtractor.
15. To design and construct a RC phase shift Oscillator for a given frequency, f_0.
16. To design and construct a Wien-Bridge oscillator for a given Cut-off frequency.
17. To determine the parameters of the single-stage JFET amplifier (Common-Drain amplifier).
18. To design and test a Darlington current amplifier and find the following parameters:
    i. Current Gain
    ii. Voltage Gain
    iii. Bandwidth
    iv. Input and output impedance
19. To design and construct a class-A power amplifier and to determine its efficiency.
20. To Design and test the following Circuit Using 555
    i. Astable multivibrator
    ii. Monostable multivibrator

   iii. Voltage to frequency converter (voltage-controlled oscillator)
   iv. Schmitt trigger.

21. To design and study the applications 555 timer IC by operating in the monostable mode
    i. Ramp generator
    ii. Pulse width generator
    iii. Frequency divide.

ECP 1402 Analog Communication Laboratory

L-T-P: 0-0-3 **Credits: 1.5**

Experiment List:

1. Double Sideband Amplitude Modulation Transmission.
2. Double Sideband Amplitude Modulation Reception.
3. Calculation of modulation index of DSB wave by trapezoidal pattern.
4. Study of Diode Detector.
5. Single Sideband Amplitude Modulation Generation.
6. Single Sideband Amplitude Modulation Reception.
7. Operation of the Automatic Gain Control Circuit.
8. Frequency Modulation Technique.
9. Demodulation on FM signals: Ratio detector and Foster Seeley Detector.
10. Receiver Characteristics: Selectivity curve for radio receiver.
11. Sensitivity curve for radio receiver.
12. Fidelity curve for radio receiver.
13. To construct a triangular wave with the help of fundamental frequency.
14. To construct a rectangular sawtooth wave with the help of fundamental frequency and its harmonic component.
15. To construct a square wave with the help of fundamental frequency fundamental frequency and its harmonic component.

CSP 1401 Computer Organization and Architecture Laboratory	
L-T-P: 0-0-3	**Credits: 1.5**
As per the syllabus of CSL 1401.	

FIFTH SEMESTER

ECL 1501 **Digital Signal Processing** **Prerequisite: ECL 1303 or EEL 1307**

L-T-P: 3-0-0 **Course Outcome** **Credits: 3**

CO1 Find DFT of a given signal through Fast Fourier Transform Techniques
CO2 Design FIR and IIR type digital filters.
CO3 Identify filter structures and evaluate the coefficient quantization effects
CO4 Understand sample rate conversion techniques.
CO5 Compare the architectures of DSP and General-Purpose Processors

Syllabus

Introduction: **Lectures: 03**
Limitations of analog signal processing, Advantages of digital signal processing and its applications; Some elementary discrete time sequences and systems; review of LTI systems.

Z Transform: **Lectures: 05**
Review of LTI system in Z-domain and ROC, Z-Transform on sequences, Inverse Z-Transform and numericals, pole-zero, system transfer function using z-transform.

Discrete Fourier Transform: **Lectures: 08**
DFT and its properties; Linear Periodic and Circular convolution; Linear Filtering Methods based on DFT; Filtering of long data sequences; Fast Fourier Transform algorithm using decimation in time and decimation in frequency techniques; Linear filtering approaches to computation of DFT.

Digital filter structures: **Lectures: 03**
System describing equations, filter categories, direct form I and II structures, cascade and parallel communication of second order systems, linear phase FIR filter structures, frequency sampling structure for the FIR filter.

IIR Filter design technologies: **Lectures: 04**
Analog lowpass filter design techniques, methods to convert analog filters into digital filters, frequency transformations for converting lowpass filters into other types, all- pass filters for phase response compensation.

FIR filter design techniques: **Lectures: 03**
Windowing method for designing FIR filters, DFT method for approximating the desired unit sample response, combining DFT and window method for designing FIR filters, frequency sampling method for designing FIR filters.

Finite precision effects: **Lectures: 02**
Fixed point and Floating-point representations, Effects of coefficient unitization, Effect of round off noise in digital filters, Limit cycles.

Application of DSP: **Lectures: 04**
DTMF signal detection, residual sound Processing, Digital FM stereo generation, oversampling A/D, D/A converter.

Text Books:

1. Digital Signal Processing: Principles Algorithms and Applications, J. G. Proakis and D. G. Manolakis, Pearson Education, 4th Edition, 2007.
2. Digital Signal Processing, A. V. Oppenheim, R. W. Schafer, Pearson Education, 2004.
3. Digital Signal Processing: Fundamentals and Application, Li Tan, Academic Press, Elseviers.
4. Digital Signal Processing, Ramesh Babu

Reference Books:

1. Digital Signal Processing: A computer-based approach, S. K. Mitra,4th Edition, TMH, 2011.
2. Signal & Systems by Oppenheim A V, Willsky A S & Young I T, Prentice Hall.
3. Theory and Application of Digital Signal Processing, L. R. Rabiner and B. Gold, Pearson Education, 2004.
4. Digital Signal Processing, Emmanuel C. Ifeachor, Barrie W. Jervis, Pearson Education India, 2002.
5. Digital Signal Processing, D.J. DeFatta, J.G.Lucas and W. S. Hodgkiss, J Wiley and Sons.

ECL 1502 Microprocessors and Microcontrollers Prerequisite: ECL 1302
L-T-P: 3-0-0 Course Outcome Credits: 3

CO1 Understand the evolution of processor architectures
CO2 Write simple programs in assembly language of Pentium processor
CO3 Interface peripheral devices and memory with microcontrollers
CO4 Program an ARM processor for DSP Applications
CO4 Understand the evolution of processor architectures

Syllabus

Introduction to Microprocessors & Microcontrollers: Lectures: 02
General definitions of mini computers, microprocessors (8085 & 8086) and microcontrollers (8051, PIC).

80XX microprocessor: Lectures: 14
CPU Architecture, Pin configuration, Instructions, Flag structure, Addressing Modes/ Instruction Word size, Languages, Description of Instructions, Assembly directive, Assembly software programs with algorithm will be new addition to the existing chapter and it will be extended to 8086. timing diagram, Instruction cycle, fetch cycle, execute cycle: I/O read cycle, I/O Write cycle, Memory Read, Memory Write, concept and structure of interrupts, interrupt service routines.

Methods of data transfer: Lectures: 04
IN/OUT instructions with timing diagrams, programmable peripheral interfaces, display devices and DAC, ADC interfacing.

8051 Microcontroller: Lectures: 10
Introduction, addressing modes and port structure, register bank, flags, program status word, memory map, external memory access, counters and timers, interrupts, instruction set.

PIC Microcontrollers: Lectures: 10
Introduction, basic architecture, instruction set, input/output ports, timer modules, ADC module, Synchronous serial port module, I2C communication.

Text Books:
1. Microprocessor Architecture, Programming and Applications with 8085/ 8086 A, Ramesh S. Gaonkar, 5th Edition, PHI, 2002.
2. The 8051 Microcontroller and Embedded system, M.A. Mazidi, Rolin McKinlay, 2nd edition, Pearson, 2007.
3. PIC Microcontroller and Embedded Systems: Using assembly and C for PIC 18, Mazidi Muhammad Ali, 1st edition, Pearson Education India, 2008
4. Microprocessors & Interfacing, Douglas V. Hall, TMH, 2006.

Reference Books:
1. Advanced Microprocessor and Interfacing, Badri Ram, TMH, 2001.
2. The Intel Microprocessors Architecture, Programming & Interfacing, B. B. Brey, 8th Edition, Pearson and PHI, 2009.
3. Advanced Microprocessor & Peripherals, K.M. Bhurchandi & A.K. Ray, 3rd Edition, TMH, 2012.

ECL 1503 | **Fundamentals of VLSI Design** | **Prerequisite: ECL 1201**

L-T-P: 3-0-0 | **Course Outcome** | **Credits: 3**

CO1 Model the behaviour of a MOS Transistor
CO2 Design combinational and sequential circuits using CMOS gates
CO3 Identify the sources of power dissipation in a CMOS circuit.
CO4 Analyze SRAM cell and memory arrays

Syllabus

Basics of fabrication and layout **Lectures: 03**
Fabrication process flow (basic steps), stick diagrams & layout design.

Non-ideal effects in MOS: **Lectures: 03**
Channel length modulation, narrow channel width, subthreshold swing, substrate bias effect, DIBL, GIDL. Scaling and Moore's law.

MOS Inverter: **Lectures: 05**
Ideal and practical inverter characteristics (Noise Margin, Propagation delay, Speed-Power product, Fan-in, Fan-out), Transfer Characteristics-MOS, CMOS inverter, Transient Analysis of CMOS Inverter and Delay analysis.

CMOS Logic Circuits: **Lectures: 04**
NAND & NOR Gates, Complex Logic Circuits, Pseudo n-MOS logic, CMOS Full adder circuit, CMOS Transmission Gate (Pass transistor Logic).

Advanced CMOS Logic Circuits: **Lectures: 05**
Dynamic CMOS Logic, Domino CMOS Logic, Differential Cascode voltage switch logic, NORA Logic.

Sequential CMOS Logic Circuits: **Lectures: 05**
Behavior of Bi-stable elements, SR Latch Circuit, Clocked JK Latch/Master-Slave JK, CMOS D-latch and edge triggered Flip-flop.

Adders and Multipliers: **Lectures: 03**
FPGA and ASIC **Lectures: 02**
Analysis of Single stage amplifier: **Lectures: 03**
Frequency response and gain.

Physical Design: **Lectures: 03**
Basics of partition, placement, floor planning and routing

Text Books:

1. CMOS Digital Integrated Circuits, Analysis & Design by Sung-Mo Kang & Yusuf Lablebici, 4th Edition, Tata McGraw-Hill Edition, 2013.
2. Digital Integrated Circuits by Rabaey & Chandrakashan, 2nd Edition, PHI, 2003.
3. CMOS VLSI Design: A Circuits and Systems Perspective by Neil H. E. Weste, Pearson Education India, 2005
4. Design of Analog CMOS Integrated Circuits by Behzad Razavi, McGraw-Hill Education, 2000.

Reference Books:

1. Analysis & Design of Digital Integrated Circuits by David Hodges, Horace G Jackson, & Resve A Saleh, Tata McGraw-Hill Edition, 1983.
2. Digital Integrated Circuits by Kenneth William Martin, Oxford University Press, 2000.
3. VLSI Design techniques for Analog and Digital Circuits, R. L. Geiger, P. E. Allen, Noel R. Strader, McGraw-Hill International Edition, 1990.

ECL 1504 RF and Microwave Engineering Prerequisite: ECL1303
L-T-P: 3-0-0 Course Outcome Credits: 3

CO1	Recognize the limitations of existing vacuum tubes and solid-state devices at microwave frequencies.
CO2	Study the performance of specialized microwave tubes such as klystron, reflex klystron, magnetron and Travelling wave tube.
CO3	Understand the operation of passive waveguide components.
CO4	Analyze microwave circuits using scattering parameters.
CO5	Test microwave components and circuits with standard microwave bench and vector network analyzer.

Syllabus

Introduction: **Lectures: 01**
Microwave frequencies, standard frequency bands, behaviour of circuits at conventional and microwave frequencies, microwave application, review of Maxwell's equations.

Transmission lines: **Lectures: 05**
Transmission line theory, low loss radio frequency and UHF transmission line. UHF line as circuit element, quality factor of resonant transmission line section, the quarter wave line as a transformer, impedance matching, Smith chart.

Waveguide: **Lectures: 05**
Overview of guided waves; TE and TM modes in rectangular, cut off wavelength, dominant mode, attenuation in waveguides.

Microwave Components & Devices: **Lectures: 08**
N-port microwave networks. Scattering matrix representation. Reciprocal and lossless networks. Passive microwave devices: E-plane tee, H-plane tee, magic tee, attenuators, directional coupler and power dividers, resonator, ferrite devices: circulator, isolator, phase-shifter, MIC

Microwave Generators: **Lectures: 09**
Transit-time effect, limitations of conventional tubes, two-cavity and multi-cavity klystrons, reflex klystron, TWT and magnetrons. Solid state devices-transferred electron devices, avalanche diode oscillator, microwave transistor, HEMT, MESFET

Microwave Measurements Technique: **Lectures: 06**
Power measurement; calorimeter method, bolometer bridge method, thermocouples, impedance measurement, measurement of frequency and wavelength, measurement of unknown loads, measurement of reflection coefficient and VSWR

Antenna Basic **Lectures: 02**
RF and microwave antennas and their properties

Introduction to RADAR principles **Lectures: 02**
RADAR range equation, RCS, CW and pulsed RADAR.

Text Books:
1. Microwave Engineering, D M Pozar, 4th Edition, John Wiley & Sons, 2011.
2. Microwave Devices & circuits, Liao Samuel Y., Liao, 3rd Edition, Pearson Education India, 1990.
3. Microwave, S Kar
4. Antennas by John D. Kraus
5. Introduction to RADAR systems by Skolnik

Reference Books:
1. Microwaves: Introduction to Circuits, Devices and Antennas by M L Sisodia, V. L. Gupta, New Age International, 2007.
2. Foundations of Microwave Engg., R E Collin, 2nd Edition, McGraw-Hill, 2007.
3. Microwave principles, Herbert J. Reich, Van Nostrand, 1966.
4. Microwave, K. C. Gupta, John Wiley & Sons Canada, Limited, 1980.
5. Microwave techniques, D. C. Agrawal.
6. Elements of Microwave Engineering, R. Chatterjee, Prentice Hall, 1988.
7. Microwaves Active devices vacuum and solid state, M. L. Sisodia, New age international, 2006.
8. Microwave circuits and passive devices, M. L. Sisodia, G. S. Raghuvanshi, Wiley Publisher, 1987.

CSL 1501	**Computer Networks**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by Dept. of Computer Science and Engineering.	

ECP 1501 Digital Signal Processing Laboratory

L-T-P: 0-0-3 **Credits: 1.5**

Experiment List:

1. Introduction of Discrete signals.
2. Sampling of signals.
3. Cross correlation and auto correlation of two discrete sequences.
4. Convolution of two discrete sequences.
5. Discrete Fourier Transform of two discrete sequence and plot magnitude and phase spectrum.
6. Low Pass Filter and High Pass Filter (IIR) (a) Butterworth (b) Chebyshev.
7. Band Pass Filter and Band Stop Filter (IIR) (a) Butterworth (b) Chebyshev.
8. FIR Filter – Triangular Window.
9. FIR Filter – Hamming and Hanning Window.
10. FIR Filter – Blackman Window.

ECP 1502 Microprocessors and Microcontrollers Laboratory

L-T-P: 0-0-3 **Credits: 1.5**

Experiment List:

1. Addition of Two 8-bit numbers. 2. Subtraction of two 8-bit numbers 3. Addition of Two 16-Bit numbers. 4. Multiplication of two 8-bit numbers. 5. One's Complement of an 8-bit number. 6. Two's Complement of an 8-bit number. 7. Find out Square Root of 0, 1, 4, 9, 16, 25, 36, 49, 64 and 81 Using Look up 8. Display Digits 0 1 2 3 4 5 6 7 8 9 A B C D E F on the data field of screen. 9. Rolling Display "HELP 85 up" on the address and data field of screen. 10. Ascending order of a given set. 11. Descending order of a given set. 12. Multiplication by two, Employing bit rotation. 13. Combination of two hex nibbles to form one-byte number. 14. Separation of HEX number into two digits. 15. Hex number stored in location for odd or even parity.	**8085**
1. Addition of two 16-bit numbers. 2. Subtraction of two 16-bit numbers. 3. Multiplication of two 16 Bit numbers. 4. 32 Bit Division. 5. Program to read a Key and display it. 6. Search a number in an array. 7. To find the maximum no. in a given string.	**8086**

8. To sort a string of a no. of bytes in descending order.
9. Multiplication of ASCII string.
10. 1's complement of a 16-bit numbers.
11. Calculating the no. of bytes in a String.
12. 2's complement of a 16-bit numbers.
13. Square waveform Generation.
14. Ramp waveform Generation.
15. Comparing two strings.

ECP 1504 RF & Microwave Engineering Laboratory

L-T-P: 0-0-2 **Credits: 1**

Experiment List:

1. Study of Reflex Klystron Characteristics.
2. Frequency and Wavelength Measurement using Reflex Klystron.
3. Impedance Measurement of Unknown Microwave Load.
4. Determination of Polar Radiation Patterns of Horn Antenna.
5. Determination of Gain of Microwave Antenna.
6. Study of I-V characteristics of Gunn Oscillator.
7. Study of Output Power and Frequency as a Function of Bias Voltage.
8. Study of Tuning Characteristics of Gunn Diode as a Function of Micrometer Screw Position.
9. Study and Characterization of Ferrite Isolator.
10. Study and Characterization of Waveguide Based 3-port Circulator.
11. Study and Characterization Waveguide Based of Attenuator.
12. Study and Characterization of Waveguide Based Magic Tee.
13. Study and Characterization of Waveguide Based Directional Coupler.
14. Determination of Dielectric Constant of Solid Plate of Unknown Material.
15. Determination of Thickness of Solid Plate.

SIXTH SEMESTER

ECL 1601 | **Digital Communication** | **Prerequisite: ECL 1402**

L-T-P: 3-0-0 | **Course Outcome** | **Credits: 3**

CO1 Model a digital communication system.
CO2 Compute probability of error and inter symbol interference from eye diagram in data transmission.
CO3 Obtain the power spectra of digital modulated signals.
CO4 Design encoder and decoder schemes for error control.

Syllabus

Waveform Coding Techniques: **Lectures: 05**
Pulse code modulation: linear quantizer, quantization noise power calculation, signal to quantization noise ratio, non-uniform quantizer, A-law & μ-law, companding, encoding and bandwidth of PCM; differential pulse code modulation (DPCM), delta modulation, slope overload, adaptive delta modulation.

Digital Multiplexing: **Lectures: 03**
Fundamentals of time division multiplexing, electronic commutator, bit, byte interleaving T1 carrier system, synchronization and signaling of T1, TDM, PCM hierarchy, North-American CCITT standards, T1 to T4 PCM TDM system (DS1 to DS4 signals), signal format of M12 Mux for AT & T (Bell) system, bit rate calculation for DS1 to DS4 signals.

Digital Base Band Transmission: **Lectures: 06**
Line coding & its properties. NRZ & RZ types, signaling format for unipolar, polar, bipolar (AMI) & Manchester coding and their power spectra, HDB and B8ZS signaling, ISI, Nyquist criterion for zero ISI & raised cosine spectrum, matched filter receiver, derivation of its impulse response and peak pulse signal to noise ratio, correlation detector, decision threshold and error probability for binary unipolar (on-off) signaling.

Digital Modulation Techniques: **Lectures: 10**
Types of digital modulation, waveforms for amplitude, frequency and phase shift keying, method of generation and detection of coherent & non-coherent binary ASK, FSK & PSK, differential phase shift keying, quadrature modulation techniques, M-ary FSK, minimum shift keying (MSK), probability of error and comparison of various digital modulation techniques. Coherent reception of ASK, PSK and FSK, non-coherent reception of ASK, FSK, PSK and QPSK, calculation of error probability of BPSK and BFSK, error probability for QPSK.

Elements of Information Theory: **Lectures: 04**
Information: mutual information and channel capacity of a discrete memoryless channel, calculation of channel capacity of discrete memoryless and continuous AWGN channels, Hartely-Shannon law, bandwidth-S/N tradeoff.

Spread-spectrum modulation: **Lectures: 05**
Pseudo-Noise sequence, basics of spread spectrum, direct-sequence spread-spectrum communication systems, frequency-hop spread spectrum systems, other types of spread spectrum signals.

Text Books:
1. Communication Systems, Simon Haykin & Michael Moher, 5th Edition, Wiley, 2009.
2. Modern Digital and Analog Communication Systems, B. B. P. Lathi & Zhi Ding, Oxford Univ. Press, 4th Edition, 2010.
3. Communication system engineering, J. G. Proakis and Sahhi, 2nd Edition, PHI, 2001.

Reference Books:
1. Digital Communications, John G. Proakis, Masoud Salehi, 5th Edition, T Mc Graw –Hill, 2008.
2. Digital & Analog Communication systems, K.S.Shammugham, John Wiley & Sons, 2006.
3. Principles of Digital Communication, P. Chakravarti, Dhanpat Rai & Co, 2008.
4. Wireless Digital Communication, Kamilo Feher, PHI, 1995.

ECL 1602 **Linear Integrated Circuits** **Prerequisite: ECL 1401**

L-T-P: 3-0-0 **Course Outcome** **Credits: 3**

CO1 Design op-amp circuits to perform arithmetic operations.

CO2 Analyze and design linear and non-linear applications using op-amps.

CO3 Analyze and design oscillators and filters using functional ICs.

CO4 Choose appropriate A/D and D/A converters for signal processing applications

Syllabus

Differential Amplifiers: **Lectures: 10**

Advantages of differential amplifiers; MOS and BJT differential pair; Small signal and large signal operation of differential pairs; Parameters and non-ideal characteristics of differential amplifiers; differential amplifier with active load frequency response, constant current bias, current mirror, cascaded differential amplifier stages, level translator.

Operational Amplifiers and its Applications: **Lectures: 10**

Concept of operational amplifiers; Ideal operational amplifier parameters; Inverting and non-inverting configurations; Common OP AMP Ics: Input offset voltage, input bias and offset current, Thermal drift, CMRR, PSRR, Frequency response. Gain-frequency and Slew rate; DC, ac amplifiers, summing differential amplifier, V to I and I to V converters, Instrumentation amplifiers; Integrators, Differentiators; Logarithmic Amp; Multipliers; Comparators; Schmitt triggers. Limiters, log/antilog amplifiers, multipliers, function generators, waveform generators.

Filters and Tuned Amplifiers: **Lectures: 10**

Filter characteristics and specifications; First and Second Order Filter functions; First-order and second order filter network using OPAMPS (low/high/band pass/band reject/ All pass filter); Tuned Amplifiers; Basic principle; amplifiers with multiple tuned circuits; Synchronous and Stagger tuning; RF amplifiers considerations.

Waveform Generation and Shaping Circuits: **Lectures: 10**

Multivibrators – Astable, monostable and bistable circuits; bistable circuit as memory element comparator generation of square, triangular waveforms and standardized pulse using AMV and MMV; Application of 555 timer.

Text Books:

1. Analysis and Design of Analog Integrated Circuits, Gray and Meyer, 5th Edition, John Wiley & Sons, Incorporated, 2010.
2. RF Microelectronics, Behzad Razavi, 2nd Edition, Pearson Education International, 2012.
3. CMOS Analog Circuit Design, Philips E. Allen & Douglas, R. Holberg, Elsevier Publisher, 2011.
4. Op Amp and Linear ICs, R. A. Gackward, 4th Edition, PHI/Pearson Education, 2002.

Reference Books:

1. Electronic devices and Circuit Theory, Robert L. Boylestad, Louis Nashelsky, Pearson/Prentice Hall, 2009.
2. Electronic Circuits, D.L. Schilting and C. Belove, TMH.

EEL 1601 **Control Systems – I**	
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus EEL 1404 prescribed by Dept. of Electrical and Electronics Engineering.	

CSL/ECL/EEL 16XX **Program Elective – I**	
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus from the list of Program Elective courses or from the other Dept courses as and when offered.	

HUL 1601 **Macro Economics & Business Environment**	
L-T-P: 3-0-0	**AUDIT**
As per the syllabus prescribed by Dept. of Basic Science & Humanities and Social Science.	

ECP 1601 Digital Communication Laboratory

L-T-P: 0-0-3 **Credits: 1.5**

Experiment List:

1. Sampling and Reconstruction of Signal.
2. Nyquist Criterion for Sampling and Reconstruction of signal.
3. Time Division Multiplexing (TDM) Transmission
4. Time Division Multiplexing (TDM) Reception
5. Delta Modulation and Demodulation.
6. Adaptive Delta Modulation.
7. Amplitude Shift Keying (ASK) Modulation and Demodulation.
8. Frequency Shift Keying (FSK) Modulation and Demodulation.
9. Binary Phase Shift Keying (BPSK) Modulation and Demodulation.
10. Quadrature Phase Shift Keying (QPSK) Modulation and Demodulation.
11. Differential Pulse Code Modulation and Demodulation.
12. 8-QAM (Quadrature Amplitude Modulation) Modulation and Demodulation.
13. Data Formatting & Carrier Transmitter.
14. Data Formatting & Carrier Receiver.
15. Study of Analog to Digital Conversion.

ECP 1602 Linear Integrated Circuits Laboratory

L-T-P: 0-0-3 **Credits: 1.5**

Experiment List:

1. The Differential Amplifier.
2. The Op Amp Comparator.
3. The Non-inverting Voltage Amplifier.
4. The Inverting Voltage Amplifier.
5. The Op Amp Differential Amplifier.

6. Parallel-Series and Series-Series Negative Feedback.
7. Gain-Bandwidth Product.
8. Slew Rate and Power Bandwidth.
9. The Non-compensated Op Amp.
10. The Operational Transconductance Amplifier.
11. Precision Rectifiers.
12. The Triangle-Square Generator.
13. The Wien Bridge Oscillator.
14. The Integrator.
15. The Differentiator.

ECP 1603 VLSI Design Laboratory

L-T-P: 0-0-3 Credits: 1.5

Experiment List:

1. Fundamentals of TCAD simulation
2. VLSI Device Designing Methodology
3. Basic MOSFET Design
4. Electrical Characteristics of MOSFETs
5. Short channel Effect analysis of MOSFETs
6. DG FET design and characteristics
7. FinFET Design and Characteristics
8. MESFET and HEMT design
9. VHDL/Verilog for Decoder, Encoder, multiplexer, demultiplexer
10. VHDL/Verilog for Positive level triggered D-latch
11. VHDL/Verilog for Positive edge-triggered T-Flip-flop
12. VHDL/Verilog forPositive edge-triggered JK-Flip-flop
13. VHDL/Verilog for Shift registers (SISO, PISO)

ECD 1601 Industrial Training and Seminar	
L-T-P: 0-0-2	**Credits: 1**
As per the training of minimum 4 weeks undergone by the student(s) in the recess before 5^{th} or 6th Semester.	

SEVENTH SEMESTER

CSL/ECL/EEL 17XX	**Program Elective – II**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus from the list of Program Elective courses or from the other Dept courses as and when offered.	

CSL/ECL/EEL 17XX	**Program Elective – III**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus from the list of Program Elective courses or from the other Dept courses as and when offered.	

CSL/ECL/EEL 17XX	**Program Elective – IV**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus from the list of Program Elective courses or from the other Dept courses as and when offered.	

ECD 1701	**Project Phase – I**
L-T-P: 0-0-10	**Credits: 5**
As per the project decided by the student and concerned supervisor.	

ECD 1702	**Seminar**
L-T-P: 0-0-4	**Credits: 2**
Each student will be assigned a topic for Seminar (other than the topic of Project).	

MAL 1701 **Operational Research** **Prerequisite: NIL**
L-T-P: 3-0-0 **Course Outcome** **Credits: AUDIT**

CO1 Develop models for optimizing the management and production systems from the verbal description of the real system.
CO2 Make use of LPP techniques for optimization of Production mix problem in industry.
CO3 Evaluate transportation, transhipment, assignment and traveling salesman and Queuing problem.
CO4 Understanding assignment model and problem formulation.

Syllabus

UNIT I: **Lectures: 09**
Introduction to Operations Research: Basics definition, scope, objectives, phases, models and limitations of Operations Research. Linear Programming Problem – Formulation of LPP, Graphical solution of LPP. Simplex Method, Artificial variables, big-M method, two-phase method, degeneracy and unbound solutions.

UNIT II: **Lectures: 08**
Revised Simplex Method, Duality of Linear Programming Problem, Dual simplex Inventory related costs, EOO model, EPO model, Inventory models allowing shortages Inventory models allowing price discounts.

UNIT III: **Lectures: 08**
Transportation Problem. Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method and MODI method.

UNIT IV: **Lectures: 06**
Assignment model. Formulation. Hungarian method for optimal solution. Solving unbalanced problem. Traveling salesman problem and assignment problem.

Text Books:
1. Taha,H A, "Operations Research - An Introduction", Sixth Edition, Prentice Hall of India Private Limited, N. Delhi, 2004.
2. Hillier, F S, "Operations Research", First Indian Edition, CBS Publishers & Distributors, Delhi, 1994.

Reference Books:
1. P. Sankara Iyer, "Operations Research", Tata McGraw-Hill, 2008.
2. P. K. Gupta and D. S. Hira, "Operations Research", S. Chand & co., 2007.

EIGHTH SEMESTER

ECL 18XX	**Program Elective – V**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus from the list of Program Elective courses or from the other Dept courses as and when offered.	

CHL 1801	**Environmental Science**
L-T-P: 2-0-0	**PASS/FAIL**
As per the syllabus prescribed by Dept. of Basic Science & Humanities and Social Science.	

EEL/CSL/ECL 18XX	**Open Elective**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus from the list of Open Elective courses or from the other Dept courses as and when offered.	

ECD 1801	**Project Phase – II**
L-T-P: 0-0-20	**Credits: 10**
As per the project decided by the student and concerned supervisor and continuation of Project Phase–I.	

ECD 1802	**Grand Viva**
L-T-P: 0-0-4	**Credits: 2**
Each student will present themselves for Viva (as a part of their assessment) for all the courses in entire B.Tech programme.	

Open Elective(s)

ECL 1X06	**Information Theory and Coding**	**Prerequisite ECL 1601**
L-T-P: 3-0-0		**Credits: 3**
As per the syllabus prescribed and stated in list of Program Elective(s).		

ECL 1X09	**Nanoelectronic Semiconductor Device**	**Prerequisite ECL 1201**
L-T-P: 3-0-0		**Credits: 3**
As per the syllabus prescribed and stated in list of Program Elective(s).		

ECL 1X11	**CAD for VLSI**	**Prerequisite ECL 1503**
L-T-P: 3-0-0		**Credits: 3**
As per the syllabus prescribed and stated in list of Program Elective(s).		

ECL 1X14	**Wireless Sensor Networks**	**Prerequisite ECL 1402**
L-T-P: 3-0-0		**Credits: 3**
As per the syllabus prescribed and stated in list of Program Elective(s).		

ECL 1X18	**VHDL Modelling**	**Prerequisite ECL 1503**
L-T-P: 3-0-0		**Credits: 3**
As per the syllabus prescribed and stated in list of Program Elective(s).		

Program Elective(s) [PE I – V]

ECL 1X04 **Foundations of MEMS** **Prerequisite: ECL 1301**
L-T-P: 3-0-0 **Course Outcome** **Credits: 3**

CO1	Understand biosensing and transducing techniques
CO2	Understand principles of linking cell components and biological pathways with energy transduction, sensing and detection
CO3	Demonstrate appreciation for the technical limits of performance of biosensor
CO4	Apply principles of engineering to develop bio analytical devices and design of biosensors

Syllabus

Scaling Laws, Why MEMS? **Lectures: 02**

Microfabrication Techniques: **Lectures: 06**
Bulk micro machining, surface micro machining and LIGA processes.

MEMS based inertial sensors: **Lectures: 06**
Accelerometer; piezoresistive and capacitive.

MEMS based gyro and tilt sensors **Lectures: 02**

MEMS based pressure sensor – Tyre Pressure Monitoring System **Lectures: 02**

Electrostatic actuation: **Lectures: 04**
Study of electrostatically actuated micro-machined cantilever beam: Free natural mode of vibration, resonance analysis, static voltage response, pull in and pull-out phenomenon. Dynamic response to time varying electrostatic actuation

RF MEMS: **Lectures: 06**
RF switch, MEMS based inductor and capacitors, MEMS based varactors and resonators.

Optical MEMS: **Lectures: 02**
MEMS based mirrors; MEMS based optical switch

Microfluidic and Bio MEMS: **Lectures: 01**
Advantages of MEMS based fluidic system.

Micro pump and Microvalve: **Lectures: 06**
Micro pump and Micro valve, Micro nozzle and thrusters, micro needle, micro cantilever-based bio sensors, lab on a chip

MEMS based interfacing electronics: **Lectures: 04**
Variable gain instrumentation amplifier and wireless integrated micro sensors.

Text Books:
1. Analysis and design principles of MEMS devices by M. H. Bao.
2. Microsystem Design by Stephen D. Senturia, Kluwer Academic Publishers, 2001.
3. Micro and Smart system by G. K. Ananthasuresh, K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat, V. K. Aatre, Wiley, 2012.
4. Fundamentals of Microfabrication techniques, Marc Madou, CRC Press

Reference Books:
1. Micromachined Transducers Sourcebook, Gregory T. A. Kovacs, MacGraw-Hill, 1998.
2. Micromechanical Transducers: Pressure sensors, accelerometers, and gyroscopes, M-H. Bao, Elsevier publisher, NewYork, 2000.
3. MEMS, Vijay Vardan, Wiley Publication.
4. MEMS and Microsytems Design and Manufacture, Tai- Ran Hsu, TMH, 2002.
5. MEMS, Nitaigour Mahalik, Tata McGraw-Hill Education, 2008.
6. MEMS and MOEMS Technology and Applications, Rai Chaoudhary, PHI Learning, 2000.

ECL 1X05 **Antenna Engineering** **Prerequisite: ECL 1403**
L-T-P: 3-0-0 **Course Outcome** **Credits: 3**

CO1 Understand the concept of radiation through mathematical formulation
CO2 Plot the characteristics of wire and aperture antennas
CO3 Develop the performance characteristics of array antennas
CO4 Measure the antenna parameters
CO5 Understand the behavior of nature on em wave propagation

Syllabus

Antenna Basics: **Lectures: 08**
Introduction, Radiation Mechanism, Antenna Parameters-Radiation Patterns, Patterns in Principle Planes, Main Lobe and Side Lobes, Beam widths, Beam Area, Radiation Intensity, Beam Efficiency, Directivity, Gain and Resolution, Antenna Apertures, Aperture Efficiency, Effective Height, Antenna Theorems- Applicability and Proofs for equivalence of directional characteristics.

Radiation from Wires: **Lectures: 07**
Retarded Potentials, Small Electric Dipole, Quarter wave Monopole and Half wave Dipole Radiation characteristics.

Antenna Arrays: **Lectures: 07**
Two element array, Principle of Pattern Multiplication, N element Uniform Linear Arrays - Broadside, End fire Arrays, EFA with Increased directivity, Binomial Arrays, Methods of Array synthesis- Tchebyscheff Distribution and Fourier Transform Method.

HF, VHF and UHF Antennas: **Lectures: 07**
Traveling wave radiators –basic concepts, Long wire antennas-field strength calculations and patterns, V-antennas, Rhombic Antennas and Design Relations, Small Loop antennas- Concept of short magnetic dipole, Helical Antennas, Yagi-Uda Arrays, Log periodic antennas.

Microwave Antennas and Antenna Measurement Pattern: **Lectures: 08**
Reflector antennas, Flat Sheet and Corner Reflectors, Paraboloidal Reflectors, Cassegrain Feeds. Slot antennas-Babinets principle, Microstrip antennas, and Horn antennas, Lens antennas (Qualitative treatment only), Antenna Measurements-Patterns Required, Set Up, Distance Criterion, Directivity and Gain Measurements (Comparison, Absolute and Antenna Methods).

Wave Propagation: **Lectures: 10**
Concepts of Propagation- frequency ranges and types of propagations. Ground Wave propagation–characteristics, Parameters, Wave Tilt, Flat and Spherical Earth Considerations, Sky Wave Propagation-Formation of Ionospheric Layers and their characteristics, Mechanism of Reflection and Refraction, Critical Frequency, MUF & Skip Distance Calculations for flat and spherical earth cases, Optimum Frequency, Virtual Height, Ionospheric Abnormalities, Ionospheric Absorption, Fundamental Equation for Free-Space Propagation, Basic Transmission Loss Calculations, Space Wave Propagation - Mechanism, LOS and Radio Horizon, Tropospheric Wave Propagation- Radius of Curvature of path, Effective Earth's Radius, Effect of Earth's Curvature, Field Strength Calculations, M-Curves and Duct Propagation, Tropospheric Scattering.

Text Books:
1. Antennas and Radio Wave Propagation, R. E. Collin, McGraw – Hill, 1985.
2. Antennas and Wave Propagation, K. D. Prasad, Tech Publications, 3rd edition, 2001.
3. Antennas and Wave Propagation, G. S. N Raju, 1st Edition, Pearson Education, 2004.

Reference Books:
1. Antenna Theory and Practice, R. Chatterjee, New age Publisher, 2004.
2. Antenna by J. D. Kraus, Tata McGraw Hil, 2006.
3. Principles of Antenna Theory, K. F. Lee, Wiley, 1984.
4. Antenna theory, analysis and design, Constantine Balanis, 2nd edition, John Wiley & Sons, 2012.

ECL 1X06 **Information Theory and Coding** **Prerequisite: ECL 1402**
L-T-P: 3-0-0 **Course Outcome** **Credits: 3**

CO1 Understand the basic concepts of information theory, mutual information and characteristics of various types of communication noisy channels
CO2 Discuss the concepts of entropy, channel capacity and various source coding schemes
CO3 Discuss the various channel coding techniques for error-free transmission of message over a noisy channel
CO4 Understand the basic techniques of protecting information from unauthorized access and concepts of cryptography

Syllabus

Introduction: **Lectures: 25**

Entropy and mutual information for discrete ensembles, source coding, variable length coding, discrete memoryless channels, mutual information, channel capacity, channel coding theorem, differential entropy and mutual information for continuous ensembles, channel capacity for Gaussian channels, channel coding, linear block codes, and cyclic codes, convolution codes, sequential and probabilistic decoding, majority logic decoding, burst error-correcting codes, turbo codes and low-density-parity check codes.

Cryptography: **Lectures: 15**

Basic concepts on cryptography and crypto analysis, security issues; private-key encryption algorithms-stream ciphers, block ciphers, Shannon's theory; introduction to number theory – modular arithmetic, exponentiation and discrete logarithms in Galois field; public key encryption algorithms-Diffie-Hellman public-key distribution scheme, RSA public-key cryptosystem; Message authentication, hashing functions, digital signatures.

Text Books:

1. Communication Systems, S. Haykin, 4th Edition, John Wiley & Sons, New York, 2001.
2. Elements of Information Theory, T M Cover and J A Thomas, John Wiley, 1991.
3. Information Theory, Coding and Cryptography, R. Bose, Tata McGraw-Hill, 2002.

Reference Books:

1. Introduction to Cryptography with Coding Theory, Wade Trappe, Lawrence C. Washington, 2nd Edition, Pearson Education India, 2007.
2. Modern digital and Analog communications, B. P. Lathi, 3rd Edition, Oxford University Press, 2000.
3. Cryptography: Theory and Practice, D. R. Stinson, 3rd Edition, Champmen & Hall/CRC, 2006.

ECL 1X07 Sensors and Instrumentation Prerequisite: ECL 1303
L-T-P: 3-0-0 Course Outcome Credits: 3

CO1 Measure displacement using capacitive and resistive transducers.
CO2 Measure temperature and strain using appropriate transducers
CO3 Build a simple data acquisition system using DMM.
CO4 Control DMM and DSO via GP-IB and perform measurements of sensor signals

Syllabus

General Concepts of Measurement: Lectures: 10
Generalized Measurement System – Performance Characteristics – Static and Dynamic Characteristics – Errors in Measurements. Transducers and their Classifications-Sensor characteristics-emerging fields of sensor technology-basic principle of resistive, capacitive, inductive, piezoelectric transducers, Hall Effect sensors and their applications

Sensor Applications: Lectures: 06
Introduction - Acceleration Sensors-Force Measurement - Torque and Power Measurement-Flow Measurement - Temperature Measurements-Distance Measuring and Proximity Sensors-Light sensor.

Signal Conditioning: Lectures: 10
Signal conditioning requirements: drift, noise, bandwidth, signal-to-noise ratio. Instrumentation amplifier, charge amplifier, Wheatstone bridge integration, differentiation and sampling, A/D and D/A conversion, choppers, voltage to time ADC, voltage to frequency conversion.

Data Acquisition: Lectures: 07
Introduction to real-time interfacing: Elements of data acquisition and control overview of I/O process, Data Acquisition conversion, General configuration: single channel and multichannel, Data Logging, Data conversion, Digital Transmission.

Virtual Instrumentation: Lectures: 07
Introduction to LabVIEW, Block diagram and architecture of the virtual instrumentation, data flow techniques, graphical programming, VIS and sub-VIS, loops & charts, arrays, clusters, graphs, case & sequence structures, formula modes, local and global variable, string & file input.

Text Books:
1. D. Helfric and W.D. Cooper, “Modern Electronic Instrumentation and measuring techniques.”, PHI, 1990.
2. E. Jones, “Instrumentation, measurement and feedback”, Tata Mc Graw-Hill, 1986.
3. E. O. Deobelin, “Measurement Systems - Applications and design”, Tata Mc Graw-Hill, 1990.
4. Sensors and Transducers, Patranabis, D, Wheeler Publishing Co, Ltd., New Delhi, 1997.

Reference Books:
1. F. Coombs, “Electronics Instruments Handbook”, Tata Mc Graw-Hill, 1995
2. R. P. Areny and T. G. Webster, “Sensor and Signal Conditioning”, John Wiley, 1991
3. B. M. Oliver and J. M. Cage, “Electronic Measurements and Instrumentation”, Tata MGH, 1975
4. Industrial Instrumentation and Control, Buchanan, W, Butterworth-Heinemann Publishers, 1999.
5. PC Interfacing for Data Acquisition and Process Control, ISA, S. Gupta and J.P. Gupta, 2e, 1994.

ECL 1X08 **Low Power VLSI Design** **Prerequisite: ECL 1301 and ECL 1302**

L-T-P: 3-0-0 **Course Outcome** **Credits: 3**

CO1 Identify the sources of power consumption in a given VLSI Circuit
CO2 Analyze and estimate dynamic, leakage power components in a DSM VLSI circuit
CO3 Choose SRAMs/DRAMs for Low power applications
CO4 Design low power arithmetic circuits and systems
CO5 Decide at which level of abstraction it is advantageous to implement low power techniques in a VLSI system design

Syllabus

Low power Basics: **Lectures: 03**
Need for low power VLSI chips, Sources of power dissipation on Digital.

Integrated circuits: **Lectures: 03**
Emerging Low power approaches. Physics of power dissipation in CMOS devices, Subthreshold Circuit Design.

Device & Technology Impact on Low Power: **Lectures: 04**
Dynamic dissipation in CMOS, Transistor sizing & gate oxide thickness, Impact of technology Scaling, Technology & Device innovation.

Power estimation Simulation Power analysis: **Lectures: 05**
Gate level logic simulation, capacitive power estimation, static state power, gate level capacitance estimation, architecture level analysis.

Low Power Design Circuit level: **Lectures: 05**
Power consumption in circuits. Flip Flops & Latches design, high capacitance nodes, low power digital cells library.

Logic level: **Lectures: 04**
Gate reorganization, signal gating, logic encoding, state machine encoding, pre-computation logic.

Low power Architecture & Systems: **Lectures: 06**
Power & performance management, switching activity reduction, parallel architecture with voltage reduction, flow graph transformation, low power arithmetic components, low power memory design.

Leakage Power minimization Approaches: **Lectures: 04**
Variable-threshold-voltage CMOS (VTCMOS) approach, multi-threshold-voltage CMOS (MTCMOS) approach, Power gating, Transistor stacking, Dual-Vt assignment approach (DTCMOS).

Algorithm & architectural level methodologies: **Lectures: 04**
Introduction, design flow, Algorithmic level analysis & optimization, Architectural level estimation & synthesis.

Text Books:
1. Low-Power CMOS VLSI Circuit Design, Kaushik Roy, Sharat and C. Prasad, John Wiley & Sons, 2009.
2. Digital integrated circuits: a design perspective, Jan M. Rabaey, Anantha P. Chandrakasan, Borivoje Nikolic, 2nd Edition, Pearson Education, 2003.

Reference Books:
1. Practical Low Power Digital VLSI Design, Gary K. Yeap, Springer London, Limited, 1998.
2. Low power design methodologies, Jan M. Rabaey, Massoud Pedram, 2nd Ed, Kluwer Academic Publishers, 1996.

ECL 1X09 **Nanoelectronic Semiconductor Devices** **Prerequisite: ECL 1201**
L-T-P: 3-0-0 **Course Outcome** **Credits: 3**

CO1 Introduction of the basics of quantum theory and its applications in Electronics
CO2 Analysis of CMOS scaling and development of nanodevices
CO3 Analysis of emerging nanodevice and electronic transport therein

Syllabus

Introduction: **Lectures: 06**

Nanotechnology and Nanoelectronics, Top-down and Bottom-up approach, Moore's Law, Review of Semiconductor Electronics, Maxwell's Equation, Poisson Equation, Continuity Equations, carrier concentration, Carrier Transport, Drift, diffusion, density of states.

Principles of Quantum Mechanics: **Lectures: 14**

Photoelectric effect, wave nature of particles and wave-particle duality, Compton Effect, Uncertainty Principle, Schrodinger's equations and its applications, wave function and its duality and postulates. Infinite well, finite well, triangular well, potential barrier, tunnelling probability, step-potential function. Atomic orbital, Pauli-exclusion principle, optical device principle, Quantum dots, wires, and wells, Ballistic Transport.

Scaling and Nanoelectronic Devices: **Lectures: 14**

CMOS scaling: advantages and limitations. Nanoscale MOSFETs, FINFETs, Vertical MOSFETs, system integration limits (interconnect issues etc.), Tunneling Transistors, Single electron transistors, spintronics, and Junctionless Transistor.

Emerging Nano-devices: **Lectures: 08**

SOI MOSFET and FinFET; strained Si FET; Heterostructure on Insulator System; HOI MOSFET, DGFET, FinFET, NanoFET; CGAA, triangular GAA, rectangular GAA, strained channel GAA; strained channel array FinFET and GAA.

Text Books:

1. Semiconductor Physics And Devices, 3ed, An Indian Adaptation, S. M. Sze, M. K. Lee, R. S. Dhar, A. Nair, 2021 Wiley India.
2. Introduction to Nanotechnology, C.P. Poole Jr., F. J. Owens, Wiley, 2003.
3. Fundamentals of Nanoelectronics, G. W. Hanson, Pearson, 2007.

Reference Books:

1. Nanosystems: molecular, machinery, manufacturing and computation, K.E. Drexler, Wiley, 1992.
2. The Physics of Low-Dimensional Semiconductors, John H. Davies, Cambridge University Press, 1998.
3. Nanoelectronics and Information Technology (Advanced Electronic Materials and Novel Devices), Waser Ranier, Wiley-VCH, 3e, 2012.
4. Introduction to Solid State Physics, C. Kittel, Wiley, 2012

ECL 1X10 **Radar Communication** **Prerequisite: ECL 1403**
L-T-P: 3-0-0 **Course Outcome** **Credits: 3**

CO1 Understand the basic operation of pulse and CW radar systems.
CO2 Evaluate the radar performance based on pulse width, peak power and beam width.
CO3 Choose suitable tracking radar for a given problem.
CO4 Select appropriate criterion for detecting a target.
CO5 Understand the working of phased array radars and navigational aids

Syllabus

Introduction: **Lectures: 06**

Principle of detection and ranging, Radar frequencies and bands, applications, radar block diagram and operation.

Radar range equation: **Lectures: 14**

Range prediction, minimum detectable signal, receiver noise and SNR, noise temperature, pattern propagation factor, antenna gain, loss factors, jamming & clutter, accuracy of prediction, integration of radar pulses, radar cross section of targets, transmitter power, PRF and range ambiguities, system losses & propagation effects.

CW FM radar: **Lectures: 06**

Doppler Effect, CW radar, frequency-modulated CW radar, multiple-frequency CW radar.

MTI and Pulse Doppler radar: **Lectures: 14**

MTI delay lines, delay line cancellers, coherent and non-coherent mti, pulse Doppler radar, monopulse RADAR, diplexer, duplexer, phased array RADAR, digital beam forming RADAR

Text Books:

1. Introduction to Radar Systems, M. I. Skolnik, McGrawhill, 2004.
2. Introduction to Airborne RADAR, Stimson

Reference Books:

1. Radar Engineering, D. G. Rink.
2. Principles of Radar and Sonar Signal Processing, Francois Le Chevalier, Artech House, 2002.

ECL 1X11 | **CAD for VLSI** | **Prerequisite: ECL 1503**

L-T-P: 3-0-0 | **Course Outcome** | **Credits: 3**

CO1 Distinguish between DSP and FPGA based filter architectures
CO2 Compare the architectures of general-purpose processors and DSP processors
CO3 Design simple IP cores for FPGA applications
CO4 Use the CAD tools to model an FPGA design
CO5 Model and design a heterogeneous FPGA based embedded system

Syllabus

Introduction: **Lectures: 04**
VLSI design flow, Full-custom, standard-cell, gate-array and FPGA, VLSI Design automation tools.

Basic concepts of high-level synthesis: **Lectures: 04**
Partitioning, scheduling, allocation and binding.

Verilog / VHDL: **Lectures: 10**
Introduction and use in synthesis, modeling combinational and sequential logic, Procedures, assignments and control statements in Verilog, writing test benches.

Technology mapping and Test-ability issues: **Lectures: 08**

Fault modeling and simulation, test generation, design for test-ability, built-in self-test, Testing SoC's, Basic concepts of verification, Silicon Compiler.

Algorithmic Graph Theory: **Lectures: 04**
Data structure for graph representation, graph algorithms – depth first search, breadth first search, Dijkstra’s shortest path, Prim’s algorithm.

Physical design automation algorithms: **Lectures: 10**
Floor-planning, placement, routing, layout synthesis, design rule check, compaction, power and delay estimation, clock and power routing, etc. Special considerations for analog and mixed-signal designs.

Text Books:
1. VHDL: Programming by Example, Douglas Perry, McGraw-Hill Professional; 4 ed., 2002.
2. Verilog HDL, Samir Palnitkar, 2 ed, Pearson, 2004.
3. Algorithms for VLSI physical design automation, N. A. Sherwani, Kluwer Academic Publishers, 1999.

Reference Books:
1. Algorithms for VLSI Design Automation, S. H. Gerez, Wiley-India, 1999.
2. Synthesis and Optimization of Digital Circuits, Giovanni De Micheli, Tata McGraw Hill, 1994.
3. VLSI physical design automation: theory and practice, S. M. Sait and H. Youssef, World Scientific Pub. Co., 1999.
4. RTL Hardware Design using VHDL: Coding for efficiency, Portability, and Scalability, Pong P. Chu, John Wiley- & Sons Inc., Hoboken, New Jersey, 2006.
5. An Introduction to Physical Design, M. Sarrafzadeh and C. K. Wong, McGraw Hill, 1996.

ECL 1X12 — Digital Image Processing — Prerequisite: ECL 1303

L-T-P: 3-0-0 — Course Outcome — Credits: 3

CO1	Understand the need for image transforms and their properties.
CO2	Choose appropriate technique for image enhancement both in spatial and frequency domains.
CO3	Identify causes for image degradation and apply restoration techniques.
CO4	Compare the image compression techniques in spatial and frequency domains.
CO5	Select feature extraction techniques for image analysis and recognition.

Syllabus

Introduction: **Lectures: 02**

Fundamental steps in digital image processing, components of an image processing system.

Digital Image Fundamentals: **Lectures: 04**

Image sampling and quantization, some basic relationships between pixels, linear and nonlinear operations.

Image enhancement in spatial domain: **Lectures: 06**

Some basic gray level transformations, Histogram processing, Smoothing and Sharpening spatial filters.

Image enhancement in frequency domain: **Lectures: 05**

Smoothing and sharpening frequency domain filters, homo-morphic filtering.

Image segmentation: **Lectures: 06**

Detection of discontinuities, edge linking and boundary detection, thresholding, region-based segmentation, recent developments.

Image restoration: **Lectures: 06**

Noise models, restoration in the presence of noise only-spatial filtering, estimating the degradation functions, inverse filtering.

Colour Image processing: **Lectures: 02**

Color models, pseudo-color processing.

Image compression: **Lectures: 04**

Image compression models, loss-less and lossy compression.

Morphological image processing: **Lectures: 05**

Dilation and erosion, opening and closing, some basic morphological algorithms.

Text Books:

1. Digital Image Processing, R. C. Gonzalez and R. E. Woods, Pearson Education, 2006.
2. Digital picture Processing, A. Rosenfield & A. C. Kak.

Reference Books:

1. Fundamentals of Digital Image Processing, K. Jain, Pearson Education, 2007.
2. Theory and Application of Digital Signal Processing, L. R. Rabiner and B. Gold, Pearson Education, 2004.

ECL 1X13 — Satellite Communication — Prerequisite: ECL 1403

L-T-P: 3-0-0 — Course Outcome — Credits: 3

CO1	Understand the orbital and functional principles of satellite communication systems
CO2	Architect, interpret, and select appropriate technologies for implementation of specified satellite communication systems
CO3	Analyse and evaluate a satellite link and suggest enhancements to improve the link performance.
CO4	Select an appropriate modulation, multiplexing, coding and multiple access schemes for a given satellite communication link.
CO5	Specify, design, prototype and test analog and digital satellite communication systems as per given specifications

Syllabus

Introduction: Lectures: 05

Satellite communication system, communications satellites, different orbits, frequency bands, and satellite multiple access formats.

Satellite communication channel: Lectures: 05

Power flow, polarization, atmospheric losses, receiver noise, CNR, satellite link analysis for uplinks and downlinks.

Satellite transponder: Lectures: 08

Transponder model, satellite signal processing RF-RF translation, IF demodulation.

Multiple access techniques: Lectures: 10

Frequency division multiple access, amplification with multiple FDMA carriers, AM/FM conversion with FDMA, switched FDMA, synchronization, SS-time division multiple access, code division multiple access, DS CDMA, frequency-hopped, CDMA.

Satellite link design: Lectures: 07

Performance requirements and standards. Design of satellite links – DOMSAT, INSAT, INTELSAT and INMARSAT, satellite- based personal communication.

Earth station design: Lectures: 05

Configuration, antenna and tracking systems, satellite broadcasting.

Text Books:

1. Satellite Communication, D. Roddy, Mc Graw- Hill, 3rd edition, 2001.
2. Satellite Communications, T. Pratt and W. Boston, John Wiley & Sons, 2004.
3. Digital Satellite Communications, T. T. Ha, McGraw Hill, U. S. A., 2004.

Reference Books:

1. Satellite Communications, Gagliardi.
2. Satellite Communications system using design principles, M. Richharia.
3. Principles of Communication Satellite, G. D. Gordon, W. L. Morgan, John Wiley & Sons, USA, 2005.

ECL 1X14 **Wireless Sensors Networks** **Prerequisite: ECL 1402**
L-T-P: 3-0-0 **Course Outcome** **Credits: 3**

CO1 Identify the components of Wireless Sensor Networks
CO2 Understand the challenges in network coverage and routing for energy efficiency
CO3 Define node Architecture for specific applications
CO4 Program sensor network platforms using specialized operating system
CO5 Recognize upcoming challenges in Sensor Networks.

Syllabus

Overview of wireless sensor networks: **Lectures: 02**
Introduction to Adhoc networks, mobile adhoc networks and sensor networks. Challenges for wireless sensor networks, enabling technologies for wireless sensor networks.

Architectures: **Lectures: 08**
Single node architecture, hardware components, energy consumption of sensor nodes, operating systems and execution environments, network architecture, sensor network scenarios, optimization goals and figures of merit, gateway concepts

Networking sensors: **Lectures: 10**
Physical layer and transceiver design considerations, MAC protocols for wireless sensor networks, low duty cycle protocols and wakeup concepts, S-MAC, the mediation device protocol, wakeup radio concepts, address and name management, assignment of MAC addresses, routing protocols, energy, efficient routing, geographic routing.

Infrastructure establishment: **Lectures: 10**
Energy efficient topology, Clustering- LEACH, PEGASIS, ELBERA etc. Time synchronization, localization and positioning, sensor tasking and control.

Sensor network platforms and tools: **Lectures: 06**
Sensor node hardware, berkeley motes, programming challenges, node-level software platforms, node-level simulators, state-centric programming.

Application and Case studies **Lectures: 04**

Text Books:
1. Protocols and Architectures for Wireless Sensor Networks, Holger Karl & Andreas Willig, John Wiley, 2005.
2. Wireless Sensor Networks- An Information Processing Approach, Feng Zhao & Leonidas J. Guibas, Elsevier, 2007.

Reference Books:
1. Wireless Sensor Networks-Technology, Protocols, and Applications, Kazem Sohraby, Daniel Minoli, & Taieb Znati, John Wiley, 2007.
2. Wireless Sensor Network Designs, Anna Hac, John Wiley, 2003.

ECL 1X15 Numerical Techniques in Electromagnetics Prerequisite: ECL 1403
L-T-P: 3-0-0 Course Outcome Credits: 3

CO1	Understanding FEM, FDTD, MoM methods of computation
CO2	Application of computation methods to analyze simple microstrip and dipole antennas
CO3	Application of computation methods to analyze simple cavity resonators
CO4	Application of computation methods to analyze simple bandpass and bandstop filters

Syllabus

Review EM theory & EM problem: Lectures: 03
Review of EM Theory, Classification of EM Problems, boundary condition.

Review of analytical method: Lectures: 04
Separation of variable, Laplace's equation and wave equation in different coordinate system, orthogonal functions.

Finite difference method: Lectures: 06
Finite difference scheme, differencing of parabolic, hyperbolic and elliptic PDEs, application to practical boundary value problems.

Variational method: Lectures: 06

Elements of calculus of variation, construction of functionals from PDEs, Reyleigh methods, weighted residual methods, Galarin method, and practical application.

Moment methods: Lectures: 07
Elements of Integral equation, Greens function, application to quasi-static problem, scattering problems, radiation problems, etc.

Finite element method: Lectures: 07
Solution of Laplace's equation, Poission equation & wave equation, mesh generation in 2D & 3D, FEM for exterior problems.

FDTD: Lectures: 07
FDTD analysis in one and two dimensions, the FDTD grid and the Yee algorithm, numerical stability, absorbing boundary conditions and perfectly matched layers.

Text Books:
1. Numerical Techniques in Electromagnetics, M. Sadiku, CRC Press, 3rd edition, 2009.
2. Analytical and Computational methods in Electromagnetics, Ramesh Garg, Artech house, 1st edition, 2008.

ECL 1X16 **Physics of Nanoscale FET** **Prerequisite: ECL 1301**
L-T-P: 3-0-0 **Course Outcome** **Credits: 3**

CO1	Understand application and process of carrier transport, tunneling at Nano regime
CO2	Design advanced FET devices and their fundamental applications
CO3	Understanding of Multi-gate physics and its concept
CO4	Understanding the phenomenon of FET reduced to wore structures and their transport mechanisms
CO5	Strain and stress concepts and its implementation in advanced FET Devices

Syllabus

Fundamental Concepts: **Lectures: 08**
Density of states, 3D, 2D, 1D; carrier densities; ballistic transport: quantum, semi-classical; band-to-band tunneling; MOSFET and Moore's law, Koomey's law; short channel and narrow width effects; Natori's theory, degenerate, nondegenerate and general condition statistics, quantum capacitance.

SOI Nano MOSFET: **Lectures: 10**
Short channel effects; Single gate, double gate, triple gate and surround gate (GAA) structures; classical and quantum physical effects in multi-gate SOI MOSFET; Multigate FET technology: active areas of Fin, mobility and strain engineering.

Multigate Nano FET Physics: **Lectures: 10**
Double gate MOS system; impact of carrier confinement and quasi-ballistic transport; oxide thickness, and electron tunnelling; Mobility: phonon limited, interface scattering, Coulomb scattering, temperature dependence, strained double gate SOI.

Nanowire FET: **Lectures: 08**
Silicon nanowire FET, IV characteristics; electron transport, surface roughness; Bandstructure of carbon nanotubes: graphene, nanotubes, Fermi points; Carbon nanotube FETs.

Strain Engineering Nano FET: **Lectures: 06**
Strain engineered hetero-FET; Engineered substrates: virtual substrate, strained SOI; Substrate-induced Strained-Si; Double and tri-layered strain HOI system, Strain effect and thickness calculation, threshold voltage, Mobility, thickness and temperature dependence; Characterization of Strained-Si Hetero-FETs.

Text Books:
1. M. Lundstrom, and J. Guo, Nanoscale Transport: Device Physics, Modelling and Simulation, Springer, 2005.
2. Sze, S. M., Lee, M. K., Dhar, R. S., and Nair, A. R., "Semiconductor Physics and Devices and Indian Adaptation", 3rd Ed., Wiley. 2021.
3. J. P. Colinge, FinFETs and Other Multi-Gate Transistors, Springer, 2009.

Reference Books:
1. C. Kittel, Introduction to solid state physics, Wiley, New York, 1976.
2. G.W. Hanson, Fundamentals of Nanoelectronics, Pearson, 2009.
3. Semiconductor Opto Electronic Devices, Pallab Bhattacharya, 2nd Edition, Prentice Hall of India Pvt., Ltd, 2004.
4. Y. Taur and T. Ning, Fundamentals of Modern VLSI Devices, Cambridge Univ. Press, 1998.
5. B. G. Streetman and Sanjay Banerjee, Solid State Electronic Devices, Pearson, 2008.

ECL 1X17 Semiconductor Process Technology Prerequisite: ECL 1301
L-T-P: 3-0-0 Course Outcome Credits: 3

CO1 Overview of basic CMOS process and fabrication
CO2 Understanding of semiconductor fabrication and crystal growth
CO3 Understand basics of front-end and back-end processes
CO4 CMOS integration and packaging of devices to be understood

Syllabus

Introduction: Lectures: 03
Integrated Circuits and Planar Process, IC Families, CMOS Process flow.

Fabrication Laboratory and Crystal Growth for VLSI Technology: Lectures: 07
Environment, Semiconductor technology trend, clean rooms, Wafer cleaning, Semiconductor Substrate Phase diagram and solid solubility, Crystal structure, Crystal defects, Czochralski growth, Bridgman growth of GaAs, Float Zone growth, Wafer Preparation and specifications.

Front end process units: Lectures: 10
Cleaning, Etching, Lithography, Oxidation, Diffusion, Implantation, Activation, Step Coverage

Back-end process units: Lectures: 08
Contacts, Interconnects, Vias, Silicide Gates and Source/Drain Regions, IMD Deposition and Planarization, Chemical-Mechanical Polishing, Electromigration.

CMOS Process Integration Lectures: 04

Measurements and Packaging: Lectures: 05
Conductivity type, Resistivity, Hall Effect Measurements, Drift Mobility; Integrated circuit packages, Electronics package reliability; Technology trends affecting testing.

Text Books:
1. Fundamentals of Semiconductor Fabrication, G. S. May and S. M. Sze, Wiley India, 2004.
2. VLSI Technology, S. M. Sze, 2nd edition, TMH, 2004.
3. Semiconductor Devices: Physics and Technology, S. M. Sze, 2nd Edn., Wiley India, 2011.

Reference Books:
1. Silicon VLSI Technology, Fundamentals, J. D. Plummer, M. D. Deal and P. B. Griffin, Practice and Modeling, Pearson education, 2000.
2. Semiconductor Integrated Circuit Processing Technology, W. R. Runyan and K. E. Bean, Addison Wesley Publishing Company, 1990.
3. The Science and Engineering of Microelectronic Fabrication S. A. Campbell, Oxford University Press, 1996.
4. Fundamentals of Microfabrication, M. J. Madou, 2nd Edition, CRC Press, 2011.

ECL 1X18 | VHDL Modelling | Prerequisite: ECL 1603
L-T-P: 3-0-0 | Course Outcome | Credits: 3

CO1 Basic overview of VHDL (design units, data objects, signal drivers etc.)
CO2 Understand the subprograms (functions, procedures etc.)
CO3 Understand the combinational logic circuit design
CO4 Understand the asynchronous and synchronous sequential circuits design
CO5 Basics of placement, routing and architecture (CPLD and FPGA)

Syllabus

Introduction: Lectures: 05
Introduction to VHDL, design units, data objects, signal drivers, inertial and transport delays, delta delay, VHDL data types, concurrent and sequential statements.

Subprograms: Lectures: 05
Functions, Procedures, attributes, generio, generate, package, IEEE standard logic library, file I/O, test bench, component declaration, instantiation, configuration.

Combinational logic circuit design and VHDL implementation of following circuits: Lectures: 08
Fast adder, Subtractor, decoder, encoder, multiplexer, ALU, barrel shifter, 4X4 key board encoder, multiplier, divider, Hamming code encoder and correction circuits.

Synchronous sequential circuits design: Lectures: 08
Finite state machines, Mealy and Moore, state assignments, design and VHDL implementation of FSMs, Linear feedback shift register (Pseudorandom and CRC).

Asynchronous sequential circuit design: Lectures: 08
Primitive flow table, concept of race, critical race and hazards, design issues like metastability, synchronizers, clock skew and timing considerations.

Placement, Routing and Architecture: Lectures: 06
Introduction to place & route process, Introduction to ROM, PLA, PAL, Architecture of CPLD and FPGA. Digital system design using FPGA.

Text Books:
1. Fundamentals of Digital Logic with VHDL design, Stephen Brown, Zvonko Vranesic, 3e, TMH, 2008.
2. VHDL, Douglas Perry, TMH, 3rd edition, 1998.
3. Digital Design Principles, Fletcher.
4. VHDL Synthesis, J Bhasker.
5. VHDL Primer, J Bhasker, Pearson Education.

Reference Books:
1. Digital System Design Using VHDL, Chales H. Roth.
2. Digital System Design, John Wakerley.
3. VHDL, Zainalabedin Navabbi.
4. VHDL, D. Smith.

ECL 1X19 Detection and Estimation Theory Prerequisite: ECL 1403
L-T-P: 3-0-0 Course Outcome Credits: 3

CO1 Understand the basics of detection and estimation theory
CO2 To understand and develop the ability to design, automated systems for detection and estimation
CO3 Examine the detection of deterministic and random signals using statistical models
CO4 Understand various estimation schemes such as ML and MMSE estimators
CO5 Analyzing signal estimation in time domain using filters

Syllabus

Background material: **Lectures: 02**
Recap of probability, calculus, and linear algebra.

Estimation theory: **Lectures: 04**
Minimum variance unbiased estimation, best linear unbiased estimation, cramer-rao lower bound (CRLB).

Maximum likelihood estimation (MLE): **Lectures: 04**
Exact and approximate methods: EM, alternating max, etc.

Bayesian inference & least squares estimation: **Lectures: 06**
Basic ideas, adaptive techniques, Recursive LS, kalman filtering (sequential Bayes).

Finite state hidden markov models: **Lectures: 06**
Forward-backward algorithm, viterbi (ML state estimation), parameter estimation (f-b + EM), and graphical models.

Applications: **Lectures: 06**
Image processing, speech, communications. Sparse recovery and compressive sensing introduction.

Monte-Carlo methods: **Lectures: 06**
Importance sampling, MCMC, particle filtering, applications in numerical integration (MMSE estimation or error probability computation) and in numerical optimization (e.g., annealing).

Detection theory: **Lectures: 06**
Likelihood ratio testing, bayes detectors, minimax detectors, multiple hypothesis tests, neyman pearson detectors (matched filter, estimator correlator etc), wald sequential test, generalized likelihood ratio tests (GLRTs), wald and RAO scoring tests, applications.

Text Books:
1. Detection, Estimation, and Modulation Theory, H.VanTrees.
2. Fundamentals of Statistical Signal Processing VolI: Estimation Theory, S.M. Kay.
3. Fundamentals of Statistical Signal Processing VolII: Detection Theory, S.M. Kay.

Reference Books:
1. Linear Estimation, Kailath, Sayed and Hassibi.
2. An Introduction to Signal Detection and Estimation, V. Poor.
3. Monte Carlo Strategies in Scientific Computing, J.S. Liu, Springer-Verlag, 2001.
4. Stochastic Simulation, B.D. Ripley, Wiley, 1987.

ECL 1X20 **Wireless Communication** **Prerequisite: ECL 1303**
L-T-P: 3-0-0 **Course Outcome** **Credits:3**

CO1 Understand the evolution of cellular communication systems up to and beyond 3G
CO2 Design a cellular link and estimate the power budget.
CO3 Choose proper multiple accessing methods depending on channel model
CO4 Identify traffic channels for call processing
CO5 Calculate key performance metrics of a cellular communication system.

Syllabus

Wireless Communication Systems & Standards: **Lectures: 07**
Evolution of Mobile Radio Communications, Cellular telephone systems, Different generations (1G to 4G) of wireless communication and Networks; GSM, GPRS, EDGE, CDMA, UMTS, WLAN, WLL, Bluetooth, PAN, Recent advances in mobile computing.

Propagation & Fading: **Lectures: 08**
Review of Path losses in indoor and outdoor propagation channels, Multipath fading, Doppler shift, time and frequency dispersive channels, delay spread and coherence bandwidth, flat and frequency selective fading, slow and fast fading, coherence time, LCR and ADF.

The Cellular Concept: **Lectures: 06**
Frequency Assignment and Channel Assignment, Frequency Reuse, Handoff, Sectoring, Repeaters for range extension, Microcell zone, Spectral efficiency & capacity of cellular systems.

Mobile Radio Interferences & System Capacity: **Lectures: 05**
Co-channel Interference and System Capacity, Channel planning for Wireless Systems, Adjacent channel interferences, Power control for reducing interference, Near-end-to-far-end interference, Inter-symbol and Simulcast interference, False alarm rate and word error rate.

Multiple access schemes: **Lectures: 03**
FDMA, TDMA, CDMA and SDMA.

Diversity & Combining Techniques: **Lectures: 07**
Diversity Schemes (Space, frequency, field and polarization diversities) and combining techniques, diversity receivers- selection, MRC & EGC. RAKE receiver, equalization linear- ZFE and adaptive, DFE.

Antennas for wireless communication: **Lectures: 04**
Antennas used for Mobile Communications, Radiation patterns, antennas for mobile terminal, base station antennas, Smart antenna (basic concept).

Text Books:
1. Wireless Communication: Principles & Practice, T. S. Rappaport, Prentice Hall, 2e, 2002.

Reference Books:
1. Mobile Cellular Telecommunications Systems, W. C. Y. Lee, TMH, 2e, 2002.
2. Wireless communication, Andrea Goldsmith, Cambridge University press, 2005.

ECL 1X21 Semiconductor Materials and Systems Prerequisite: ECL 1301

L-T-P: 3-0-0 Course Outcome Credits: 3

CO1 To analyse the physics and properties of Semiconductor

CO2 To analyse the optoelectronic properties and physics of semiconductor materials

CO3 To analyse the junction electronics and material physics of Semiconductor

CO4 To understand and analyse the electronic materials for semiconductor devices

Syllabus

Semiconductor properties and Band Structure: Lectures 12

Crystal structure, intrinsic and doped crystals, excess carriers and current transport, Band structure, carrier energy and Fermi distributions for free carriers, donor and acceptor impurities, determination of band gap, impurity ionization, and critical temperatures for intrinsic ionization and onset of impurity deionization, Impurity diffusion processes and profile derivations, built-in electric field and carrier profiles.

Optoelectronic properties: Lectures 08

Optical processes in semiconductors, EHP formation and recombination, absorption and radiation, deep level transitions, Auger recombination, luminescence and time resolved photoluminescence, optical properties of photonic band-gap materials.

Junction electronics: Lectures 12

p-n junction, tunnel diode, quasi-Fermi levels, depletion width capacitance and its application in doping profile determination, I-V characteristics of narrow and wide base diodes, breakdown mechanisms, PIN, heterojunction and avalanche photodiode, Comparisons of various photodetectors, measurement techniques for output pulse.

Electronic Material and devices: Lectures 10

Formation of bipolar and FET transistors, current gains, drift and graded base transistors, Surface states, measurement of surface charge, Q-V/I-V characteristics, Dynamic effects of MOS capacitor, basic structure and response of charge coupled devices, buried channel charge coupled devices.

Text Books:

1. Solid State Physics, Ashcroft amd Mermin, Thomson Press (India) Ltd, 2003
2. Sze, S. M., Lee, M. K., Dhar, R. S., and Nair, A. R., “Semiconductor Physics and Devi and Indian Adaptation”, 3rd Ed., Wiley. 2021
3. The Physics of Low-Dimensional Semiconductors, John H. Davies, Cambric University Press, 1998.

Reference Books:

1. Eshraghian, K., Pucknell, D.A. and Eshraghian, S., “Essentials of VLSI Circuit a System”, 2nd Ed., Prentice-Hall of India. 2005
2. Glover, I.A., Pennoek, S.R. and Shepherd P.R., “Microwave Devices, Circuits and Su Systems”, 4th Ed., John Wiley & Sons. 200
3. Golio, M., “RF and Microwave Semiconductor Devices Handbook”, CRC Press
4. Liao, S.Y., “Microwave Devices and Circuits”, 4th Ed., Pearson Education.

ECL 1X22 **Optoelectronic Devices** **Prerequisite: ECL 1301**

L-T-P: 3-0-0 **Course Outcome** **Credits: 3**

CO1	Introduction of the fundamentals of quantum theory applications
CO2	Introducing the basic band structure and quantized theory for optoelectronics
CO3	Analyse electromagnetics and waveguides wrt optical quantum systems
CO4	Understanding the principle of semiconductor and THZ QC lasers

Syllabus

Fundamentals of Quantum Theory: **Lectures 07**

Schrodinger's Equation, Square well, Harmonic Oscillator, Hydrogen Atom (3D and 2D Exciton Bound and Continuum States), Time-Independent Perturbation Theory, Lowdin's Renormalization Method, Time-Dependent Perturbation Theory.

Theory of Electronic Band Structures: **Lectures 08**

Bloch Theorem and K.p method, Kane's model for band structure, k.p method spin orbit, Kronig-Penney Model for a Superlattice, Band Structures of Semiconductor Quantum Wells.

Electromagnetics and Waveguides **Lectures 12**

Maxwell equations, Coulomb gauge, Lorentz gauge, duality principle; Plane wave reflection from a layered media; Propagation matrix approach; Optical Waveguide Theory; Symmetric and Asymmetric Dielectric slab waveguides; Wave guidance in a lossy or gain medium.

Semiconductor Lasers: **Lectures 10**

Optical Transitions Using Fermi's Golden Rule, Spontaneous and Stimulated Emissions, Double Hcterojunction Lasers, Quantum-Well Lasers, gain Gain-guided and index guided lasers.

THz Quantum Cascade Lasers: **Lectures 05**

Introduction to QCL, Density Matrix Modeling, Experimental results, New active region design, Intra-cavity THz generation, THz imaging lasers, Inter-cavity and voltage distribution study.

Text Books:

1. Solid State Physics, Ashcroft amd Mermin, Thomson Press (India) Ltd, 2003
2. Physics of Optoelectronics Devices, Shun Lien Chuang, Wiley 1995.

Reference Books:

1. Sze, S. M., Lee, M. K., Dhar, R. S., and Nair, A. R., "Semiconductor Physics and Devices and Indian Adaptation", 3rd Ed., Wiley. 2021.
2. The Physics of Low-Dimensional Semiconductors, John H. Davies, Cambridge University Press, 1998.
3. C. Kittel, Introduction to solid state physics, Wiley, New York, 1976.

CSL 1XXX	**Software Engineering**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by the Department of Computer Science & Engineering.	

CSL 1XXX	**Artificial Intelligence**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by the Department of Computer Science & Engineering.	

CSL 1XXX	**Computer Graphics**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by the Department of Computer Science & Engineering.	

CSL 1XXX	**Machine Learning**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by the Department of Computer Science & Engineering.	

CSL 1XXX	**Bioinformatics**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by the Department of Computer Science & Engineering.	

CSL 1XXX	**Optimization Techniques**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by the Department of Computer Science & Engineering.	

EEL 1XXX	**Instrumentation Engineering**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by the Dept. of Electrical & Electronic Engineering.	

EEL 1XXX	**Power Electronics and Drives**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by the Dept. of Electrical & Electronic Engineering.	

EEL 1XXX	**Soft Computing**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by the Dept. of Electrical & Electronic Engineering.	

EEL 1XXX	**Renewable Energy**
L-T-P: 3-0-0	**Credits: 3**
As per the syllabus prescribed by the Dept. of Electrical & Electronic Engineering.	