

Vidyasagar University



Midnapore-721102, West Bengal
The syllabus for M.Sc. in Electronics
With Effect from 2025-26



Preamble

Electronics is a modern subject of learning. Phenomenological changes are happening in the society with the advancement of electronics. It is imperative to have skilled manpower to accelerate the progress in our society. In this direction, M.Sc. in Electronics course at Vidyasagar University is designed to impart basic as well as advance knowledge to the students for equipping themselves in the arena of electronics.

The M.Sc. in Electronics course was initiated at Vidyasagar University in the year 2001 and later on a department of Electronics was established in the year 2004. The departmental faculty members are qualified and experienced, and are dedicated to serve the students. They are active researcher in the fields like Materials science, Optoelectronics, Microwave engineering, and Semiconductor devices. Technical and non teaching staff members are also present to serve the students

The department offers two degree courses: *M.Sc. in Electronics* and *Ph.D. in Electronics*, and one short-term course - *Electronics and E-Waste Management*. The M.Sc. in Electronics curriculum has

been designed based on Choice Based Credit System (CBCS) with the contents of modern technological aspects of electronics. It is regularly updated to impart contemporary knowledge to the students in the field of electronics. The curriculum is framed up with the courses like Materials science, Semiconductor devices, Optoelectronics, VLSI design and technology, Microwave engineering etc. The Students get on-hand exposure in technologically modern laboratories like Signal processing lab, Microprocessor and microcontroller lab, Communication lab, VLSI lab, Digital lab and Circuit design lab. In the syllabus there is also a scope to transfer credit from MOOCS courses. The final semester students may opt either for Industrial training or Project work. The syllabus also complies with all India competitive examinations like NET, GATE, SET etc.

The students are getting smart class room teaching regularly. Apart from the regular classes to the students, remedial classes are arranged for the weaker students. Coaching classes are also provided for NET, SET, GATE examinations. Special lectures, Invited talks, Seminars are arranged for the students regularly in the department.

Programme/Learning Outcome (P/LO)

After completion the M.Sc. in Electronics course, the students will be able to:

PO1: Advanced Theoretical Knowledge: Acquire strong mathematical foundation, computational skills with Python, knowledge for analog and digital circuits, electronic materials, semiconductor devices, network analysis and synthesis, control systems and instrumentation, electronic and optical communications, electromagnetism and antenna, VLSI design and technology, digital signal processing and microprocessor and microcontroller.

PO2: Practical Skill Development: Confident to work independently in circuit design lab, digital lab, microprocessor and microcontroller lab, communication lab and VLSI design lab.

PO3: Research Skill Development: Learn to identify and formulate a research problem, literature review, scientific methodology, inference drawing, report writing and public presentation.

PO4: Industrial Exposure: Exposure to industrial atmosphere and to work therein with a real problem.

PO5: Ethics and Knowledge Systems: Learn ethical principles, professional ethics, responsibilities, engineering practice norms and Indian Knowledge systems.

PO6: Team work and Collaboration: Train up for individual and teamwork.

PO7: Communication Skill: Development of communication Skill for doing work at different research organizations, Government and multi-national sectors.

PO8: Interdisciplinary Integration: Integrate mathematical knowledge with other scientific and engineering domains, promoting interdisciplinary problem-solving.

PO9: Lifelong Learning: Engage in lifelong learning to stay updated with emerging areas in Electronics, Data communication, IOT & machine learning, and scientific research.

PO10: Employability and Entrepreneurship: Demonstrate employability and entrepreneurship skills by applying theoretical knowledge in teaching, research, industry, and innovation.

Programme Specific Outcomes (PSOs)

The M.Sc. In Electronics course will help to develop skilled scientific manpower having comprehensive knowledge on electronics with an understanding of technological developments and applications of the subject. After completion of the course, a student achieves:

PSO1: State-of-the-art knowledge about various theoretical and experimental techniques that are used within the scope of this subject.

PSO2: A comprehensive knowledge in the areas of electronic materials, analog electronics, digital electronics, computer programming, electronic communications, VLSI design and technology, digital signal processing, electronic devices, computer networks, microprocessor and microcontroller etc. and acquires good theoretical and practical insight in that fields.

PS03: Ability to demonstrate practical skills in the use of tools, technologies and methods related to electronics, and apply the scientific techniques in the design and execution of experiments.

PSO4: Working on a chosen specialized area of electronics in his/her master's project and/or industrial training develops an ability to carry out a scientific work independently.

PSO5: Skills to compete in national/international level examinations such as NET/SET/GATE etc., and can pursue a career in higher studies.

PSO6: Confident to do work at various research institutes, public and private organizations.

COURSE STRUCTURE OF M.Sc. IN ELECTRONICS

Semester	COURSE NO.	COURSE TITLES	Full Marks	No. of Class	CREDIT (Lecture – Tutorial - Practical)
I	ELCC401X1	Analog Circuits & Systems (Theory)	25	20	2(2-0-0)
	ELCC401X8	Analog Circuits & Systems (Practical)	25	20	2 (0-0-2)
	ELCC402X1	Digital System Design (Theory)	25	20	2(2-0-0)
	ELCC402X8	Digital System Design (Practical)	25	20	2 (0-0-2)
	ELCC403X1	Research Methodology (Theory)	25	20	2(2-0-0)
	ELCC403X8	Research Methodology (Practical)	25	20	2 (0-0-2)
	ELCC404X0	Modern Communication (Theory)	25	20	2(2-0-0)
	ELCC405X0	Microprocessor & Microcontroller (Theory)	25	20	2(2-0-0)
	ELCC406X9	Computational Skill with Python (Practical)	25	20	2 (0-0-2)
	ELCC407X0	Network Theory (Theory)	25	20	2(2-0-0)
	ELCO408VC	Indian Knowledge System (IKS)	25	20	2(2-0-0)
	ELCO409NC	Vidyasagar : Life and Philosophy	Compulsory non-credit Course		
	Total			275	
Semester	COURSE NO.	COURSE TITLES	Full Marks	No. of Class	CREDIT (Lecture – Tutorial - Practical)
	ELCC451X1	Semiconductor Device (Theory)	25	20	2(2-0-0)
	ELCC451X8	Semiconductor Device (Practical)	25	20	2 (0-0-2)
	ELCC452X0	Signal and Systems (Theory)	25	20	2(2-0-0)
	ELCC453X9	Microprocessor (Practical)	25	20	2 (0-0-2)

II	ELCC454X0	E. M. Theory (Theory)	25	20	2(2-0-0)
	ELCC455X0	Numerical Analysis (Theory)	25	20	2 (0-0-2)
	ELCC456X0	Electronic Material (Theory)	25	20	2(2-0-0)
	ELCC457X0	Applied Optics & Photonics (Theory)	25	20	2(2-0-0)
	ELCC458X0	Control System (Theory)	25	20	2(2-0-0)
	ELCC459X0	Computer Network (Theory)	25	20	2 (2-0-0)
	ELCO460X9	Field Visit/ Industrial Visit	25	20	2 (0-0-2)
	Total		275		22
	Total: First Year of PG		550		44
Semester	COURSE NO.	COURSE TITLES	Full Marks	No. of Class	CREDIT (Lecture – Tutorial - Practical)
III	ELCO501X0	MOOCs	50	40	4(4-0-0)
	ELCC502X0	Microwave Technology (Theory)	25	20	2(2-0-0)
	ELCC503X9	Communication and Microwave (Practical)	25	20	2 (0-0-2)
	ELCE504A0	Quantum Electronics (Theory)	50	40	4(4-0-0)
	ELCE504B0	RF and Antenna Design	50	40	4(4-0-0)
	ELCE504C0	Power and Industrial Electronics	50	40	4(4-0-0)
	ELCE505A0	Nano material & Characterization	50	40	4(4-0-0)
	ELCE505B0	Satellite & Mobile Communication	50	40	4(4-0-0)
	ELCE505C0	Network Security and Cryptography	50	40	4(4-0-0)
	ELCC506X1	VLSI Technology (Theory)	25	20	2(2-0-0)
	ELCC506X8	VLSI Technology (Practical)	25	20	2 (0-0-2)
	ELCO507X9	Social Service/ Community Engagement (NSS/Outreach)	25	20	2
Total		275		22	
Semester	COURSE NO.	COURSE TITLES	Full Marks	No. of Class	CREDIT (Lecture – Tutorial - Practical)
IV	ELCE551A0	System Design through Verilog	50	40	4(4-0-0)
	ELCE551B0	Optical Communication	50	40	4(4-0-0)
	ELCE551C0	IOT & Internet Technology	50	40	4(4-0-0)

	ELCE551D0	Industrial Instrumentation	50	40	4(4-0-0)
	ELCE552A0	Semiconductor Packaging and Testing	50	40	4(4-0-0)
	ELCE552B0	Radar Signal & Processing	50	40	4(4-0-0)
	ELCE552C0	Embedded System	50	40	4(4-0-0)
	ELCE552D0	Optimization, Machine Learning and AI	50	40	4(4-0-0)
	ELCC553X9	Research Project / Dissertation	100	NA	8 (0-0-8)
	ELCC554X9	Internship/ Applied Field and Industry Project/ Start Up proposal and Practice	50	NA	4(0-0-4)
	ELCO555X0	IPR/ Hardware Maintenance	25	20	2
	Total		275		22
	Total: Second Year of PG		550		44

Distinctive features of course content:		
Feature	Course Code	Program-wise percentage of courses#
Value added course	ELCC403X1 Research Methodology(Theory)	9%
	ELCO408VC Indian Knowledge System (IKS)	
	ELCO409NC Vidyasagar : Life and Philosophy	
	ELCO507X9 Social Service/ Community Engagement (NSS/Outreach)	
	ELCO555X0 IPR/ Hardware Maintenance	
Employability/Entrepreneurship/skill development	ELCO460X9 Field Visit/ Industrial Visit	36%
	ELCC506X1 VLSI Technology (Theory)	
	ELCE505C0 Network Security and Cryptography	
	ELCO501X0 MOOCs	
	ELCE551C0 IOT & Internet Technology	
	ELCE551D0 Industrial Instrumentation	
	ELCE552A0 Semiconductor Packaging and Testing	
	ELCE552C0 Embedded System	
	ELCE552D0 Optimization, Machine Learning and AI	
	ELCC553X9 Research Project / Dissertation	
	ELCC554X9 Internship/ Applied Field and Industry Project/ Start Up proposal and Practice	
Digital content	ELCC406X9 Computational Skill with Python (Practical)	4.54%
	ELCC506X8 VLSI Technology (Practical)	
New Course Introduced	ELCC403X1 Research Methodology(Theory)	31.8%
	ELCC403X8 Research Methodology (Practical)	
	ELCO408VC Indian Knowledge System (IKS)	
	ELCO409NC Vidyasagar : Life and Philosophy	
	ELCO460X9 Field Visit/ Industrial Visit	

	ELCE504A0 Quantum Electronics (Theory)	
	ELCE504B0 RF and Antenna Design	
	ELCE505B0 Satellite & Mobile Communication	
	ELCE505C0 Network Security and Cryptography	
	ELCO507X9 Social Service/ Community Engagement (NSS/Outreach)	
	ELCE551A0 System Design through Verilog	
	ELCE551C0 IOT & Internet Technology	
	ELCE551D0 Industrial Instrumentation	
	ELCE552A0 Semiconductor Packaging and Testing	
	ELCE552B0 Radar Signal & Processing	
	ELCE552C0 Embedded System	
	ELCE552D0 Optimization, Machine Learning and AI	
	ELCO555X0 IPR/ Hardware Maintenance	

Paper: ELCC401X1
Analog Circuits and Systems (Theory), FM: 25, Credit: 02, Lecture period: 20 Hours

1. Review of Diode: Applications of diode: rectifier, clipper, clamper, voltage doubler.
2. BJT: BJT biasing, stabilization, methods of stabilization, transfer characteristics of BJT, BJT acts as a switch and a amplifier, small signal analysis of BJT, CB,CE and CC amplifiers, derivation of voltage gain, current gain, input impedance and output impedance, frequency response characteristics, high frequency model of BJT.
3. MOSFET: MOSFET operation, small signal and large signal model of a MOSFET. CMOS inverter, MOSFET as a switch and an amplifier, MOS biasing, CS, CD, and CG amplifier using MOSFET.
4. Feedback Amplifiers: Feedback topologies, feedback amplifiers, determination of loop gain, stability of amplifier, Frequency compensation. Hartley, Colpitt's and Phase Shift oscillators.
5. OPAMP: Application of OPAMP, differentiators, integrators, active filters, Comparator, Schmitt triggers, Instrumentation Amplifiers, Logarithmic Amplifiers, Anti-log amplifiers, wave generator.
6. Regulated power supply, voltage regulator using discrete component, series regulation using OP-AMP, details of standard power supply unit, switch mode power supply (SMPS)

Course Outcome (COs)

After completing this course students will acquire knowledge on the following subjects

- Acquire basis concept of different electronic devices.
- Able to design amplifier circuits using Diode, BJT, MOSFET and OP- AMP and learn their different important characteristics.
- Learn about power supply

Recommended Books:

1. Robert L. Boylestad & Louis Nashelsky – *Electronic Devices and Circuit Theory*
2. Adel S. Sedra & Kenneth C. Smith – *Microelectronic Circuits*
3. Jacob Millman & Christos C. Halkias – *Integrated Electronics: Analog and Digital Circuits and Systems*
4. Robert F. Coughlin & Frederick F. Driscoll – *Operational Amplifiers and Linear Integrated Circuits*
5. Albert Paul Malvino & David J. Bates – *Electronic Principles*
6. Ramakant A. Gayakwad – *Op-Amps and Linear Integrated Circuits*
7. Paul Horowitz & Winfield Hill – *The Art of Electronics*
8. David A. Bell – *Electronic Devices and Circuits*

Paper: ELCC401X8

Analog Circuits and Systems (Practical), FM: 25, Credit: 02

1. To study fixed bias circuit of a BJT amplifier: To design a fixed bias transistorized amplifier and measure VBE, VCE, VCB, IC, IB, IE at Q point. Repeat the same with different BJT.
2. To study of self-biased transistorized amplifier: To design a self bias transistorized amplifier and measure VBE, VCE, VCB, IC, IB, IE at Q point. Repeat the same with different BJT.
3. To study the Frequency response of voltage divider bias circuit of BJT on emitter load RE. Study frequency response of voltage divider bias circuit of BJT. To measure midband gain, input impedance and output impedance.
4. To study frequency response of voltage divider bias circuit of BJT using shunted emitter load. Study frequency response of voltage divider bias circuit of BJT. Measure midband gain, input impedance and output impedance. Perform linearity test for given configuration.
5. To study frequency response of emitter follower of BJT: Study frequency response of emitter follower of BJT. Measure of mid band gain, input impedance and output impedance.
6. To design a R-C coupled amplifier of given gain using transistors in CE mode. i) Study the frequency response and calculate its bandwidth. ii) Connect a buffer (C-C amplifier) at the final stage and find its effect.
 - a) To construct a regulated power supply using a power transistor as a pass element and an OPAMP as a comparator.
 - b) Design of variable power supply using LM 317.
7. To design an active first and second order Butterworth filter and study its frequency response characteristics and find the cut-off frequencies.
8. To design of RC phase shift oscillator.
9. To design and Integrator and Differentiator using OP-AMP and draw the transfer characteristics.

Course Outcome (COs)

This is a practical paper on the design of analog circuits in advance level. At the end of course the students are able to:

- Design filters, amplifiers using transistors, regulated power supply, and uses OPAMP to design circuits for integration and differentiation etc. The design process is carried out by using breadboard and discrete electronic components.
- To correlate the theoretical concept of electronic circuit with practical feasibility.
- To acquire experience on electronic circuits for real life applications.

Recommended Books:

1. Robert L. Boylestad & Louis Nashelsky – *Electronic Devices and Circuit Theory*
2. Thomas L. Floyd – *Electronic Devices*
3. Jacob Millman & Christos C. Halkias – *Integrated Electronics: Analog and Digital Circuits and Systems*
4. Robert F. Coughlin & Frederick F. Driscoll – *Operational Amplifiers and Linear Integrated Circuits*
5. Ramakant A. Gayakwad – *Op-Amps and Linear Integrated Circuits*
6. Albert Paul Malvino & David J. Bates – *Electronic Principles*
7. K. A. Navas – *Electronic Circuits Laboratory*
8. S. Salivahanan, N. Suresh Kumar & A. Vallavaraj – *Electronic Devices and Circuits Laboratory Manual*

Paper: ELCC402X1

Digital System Design (Theory), FM: 25, Credit: 02, Lecture period: 20 Hours

1. Logic gates- NOT, AND, OR, NAND, NOR, Ex-OR, Boolean algebra and Karnaugh map simplification SOP and POS form.
2. Combinational Circuit: Analysis and synthesis of combinational circuits, multiplexer, de-multiplexer, encoder, decoder, code-converter, adder, subtractor, comparator, parity generator/checker.
3. Sequential Circuit : Analysis and synthesis of sequential circuits, S-R, D, T, J-K flip-flop, Master – Slave flip-flop, Flip-Flop Conversion, Synchronous & asynchronous counter, register, shift register, Ring and Johnson Counter.
4. Converters: Specification of converter, R-2R ladder type D/A converter, Successive approximation converter.
5. Finite state machine: Analysis and design of fundamental mode state machines: State variables, State table and

Course Outcome (COs)

- Acquire fundamental idea of logic gates and Boolean algebra.

- Obtain knowledge about different combinational logic circuits and sequential logic circuits.
- Acquire knowledge to understand ADC/DAC.
- Acquire knowledge about finite state machine and State diagram.

Recommended Books:

1. M. Morris Mano & Michael D. Ciletti – *Digital Design*
2. Thomas L. Floyd – *Digital Fundamentals*
3. Ronald J. Tocci, Neal S. Widmer & Gregory L. Moss – *Digital Systems: Principles and Applications*
4. Donald P. Leach & Albert Paul Malvino – *Digital Principles and Applications*
5. Charles H. Roth Jr. & Larry L. Kinney – *Fundamentals of Logic Design*
6. John F. Wakerly – *Digital Design: Principles and Practices*
7. R. P. Jain – *Modern Digital Electronics*
8. A. Anand Kumar – *Fundamentals of Digital Circuits*

Paper: ELCC402X8

Digital System Design (Practical), FM: 25, Credit: 02

1. Design and Implementation of half adder and full adder circuit.
2. Design and Implementation of multiplexer and demultiplexer circuit.
3. Design and Implementation of magnitude comparator circuit.
4. Design and Implementation of code converter.
5. Design and Implementation of flip flops.
6. Design and Implementation of counter.
7. Design and Implementation of register.
8. Design and implementation of D/A using R-2R ladder.

Course Outcome (COs):

At the end of this course students will.

- Design different combinational and sequential circuits like adder, multiplexer, flip-flops, registers, counters using bread board and ICs
- Learn to correlate the theoretical concept of digital circuits with practical feasibility.
- Gather on hand experience on digital circuits for solving real life problems.

Recommended Books:

1. M. Morris Mano & Michael D. Ciletti – *Digital Design*
2. Thomas L. Floyd – *Digital Fundamentals*
3. Ronald J. Tocci, Neal S. Widmer & Gregory L. Moss – *Digital Systems: Principles and Applications*
4. Charles H. Roth Jr. & Larry L. Kinney – *Fundamentals of Logic Design*
5. Donald P. Leach & Albert Paul Malvino – *Digital Principles and Applications*
6. R. P. Jain – *Modern Digital Electronics*
7. A. Anand Kumar – *Fundamentals of Digital Circuits*
8. John F. Wakerly – *Digital Design: Principles and Practices*

Paper: ELCC403X1

Research Methodology (Theory), FM: 25, Credit: 02, Lecture Period: 20 Hours

1. Research: Meaning, Types and Characteristics, Positivism and Post-positivism approach in research,
2. Methods of research: Experimental, Descriptive, Historical, Qualitative and Quantitative methods.
3. Steps of research.
4. Thesis and article writing: Format and styles of referencing. Paper, Article, Workshop, Seminars, Conference, Symposium.
5. Applications of ICT in research.
6. Research ethics.

Course Outcome (COs)

After completing this course the students will acquire knowledge on the following subject

- To develop primary knowledge on how to do research.
- Application of ICT in research
- Develop presentation skill in research.

Recommended Books:

1. C. R. Kothari & Gaurav Garg – *Research Methodology: Methods and Techniques*
2. John W. Creswell & J. David Creswell – *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*
3. Wayne C. Booth, Gregory G. Colomb & Joseph M. Williams – *The Craft of Research*
4. Sharan B. Merriam & Elizabeth J. Tisdell – *Qualitative Research: A Guide to Design and Implementation*
5. Kate L. Turabian – *A Manual for Writers of Research Papers, Theses, and Dissertations*
6. Diana Hacker & Nancy Sommers – *A Writer's Reference*
7. Robert A. Day & Barbara Gastel – *How to Write and Publish a Scientific Paper*
8. Nicholas Walliman – *Research Methods: The Basics*

Paper: ELCC403X8
Research Methodology (Practical), FM: 25, Credit: 02

Write programs using C Programming Language to perform the following tasks: List of Assignments: Find factorial of an integer N, Prime or non-prime, Fibonacci Series, Armstrong Number, decimal to binary conversion, Sum of AP Series or GP series, Calculation of the functions $\sin(x)$, $\cos(x)$ and $\exp(x)$ by representing each of them as an infinite series, Sort an array of numbers in (a) ascending and (b) descending order using the Bubble sort algorithm. Solve a given polynomial equation numerically using (a) Newton-Raphson method (b) Bisection method

Course Outcome (COs)

After completing this course the students will acquire knowledge on the following subject

- To acquire programming skills in C on various mathematical functions required for research.
- To acquire programming skill on numerical analysis.
- To develop the ability to write database applications using C.

Recommended Books:

1. Brian W. Kernighan & Dennis M. Ritchie – *The C Programming Language*
2. E. Balagurusamy – *Programming in ANSI C*
3. Byron S. Gottfried – *Programming with C*
4. Herbert Schildt – *C: The Complete Reference*
5. Yashavant Kanetkar – *Let Us C*
6. B. S. Grewal – *Numerical Methods in Engineering and Science*
7. S. S. Sastry – *Introductory Methods of Numerical Analysis*
8. Steven C. Chapra & Raymond P. Canale – *Numerical Methods for Engineers*

Paper: ELCC404X0
Modern Communication (Theory), FM 25, Credit 2, Lecture period: 20 Hours

1. Fundamentals of Analog Communication: Elements of a communication system, Need for modulation, Principles of Amplitude Modulation (AM), Generation and detection of AM: DSB, SSB, VSB, Principles of Frequency Modulation (FM), FM generation and detection, comparison of AM and FM.
2. Noise in Communication Systems: Introduction to noise, Internal and external noise sources. Noise temperature, Noise figure, Equivalent noise bandwidth. Effect of noise in AM systems, SNR in envelope and coherent detection. Effect of noise in FM receivers, pre-emphasis and de-emphasis.
3. Digital and Mobile Communication: Need for digital communication, overview of sampling, quantization Encoding, PCM, ASK, FSK, PSK and QAM, Applications and bandwidth considerations of digital modulation, Introduction to Mobile Communication: cellular concept, frequency reuse, Overview of generations (2G to 5G), features & applications.

4. Optical & Modern Communication Technologies: Introduction to optical communication, optical fibers, structure, Attenuation and dispersion in fibers, bandwidth advantage. Optical transmitter and receiver basics, Applications of optical communication in telecommunication, Overview of IOT, WiFi, GPS as modern communication applications.

Course Outcome (COs):

After completion of this course the students will be able to:

- Acquire fundamental knowledge on analog communication system like AM, FM and PM The various techniques of modulation and demodulation.
- Understand the digital modulation system, information theory and data communication.
- Develop problem solving skills on analog and digital communication systems.

Recommended Books:

1. Simon Haykin – *Communication Systems*
2. B. P. Lathi & Zhi Ding – *Modern Digital and Analog Communication Systems*
3. George Kennedy & Bernard Davis – *Electronic Communication Systems*
4. Wayne Tomasi – *Electronic Communications Systems: Fundamentals Through Advanced*
5. Dennis Roddy & John Coolen – *Electronic Communications*
6. Theodore S. Rappaport – *Wireless Communications: Principles and Practice*
7. Gerd Keiser – *Optical Fiber Communications*
8. Behrouz A. Forouzan – *Data Communications and Networking*

Paper: ELCC405X0

Microprocessor and Microcontroller (Theory) Full Marks: 25, Credit: 02, Lecture period: 20 Hours

1. Introduction to Microprocessor 8086: Architecture, Functional block diagram, Register organization, Memory organization, Programming modes, Memory access, Physical memory organization, Signal description of different pins, Timing diagram, Addressing modes, Instruction set, Simple program development using instructions, Interrupts, Memory and I/O interfacing – Memory mapped I/O and peripheral I/O, Interfacing switches and LEDs, Interfacing data converters.
2. Microcontroller 8051: Architecture, Memory organization, Internal RAM structure-- Special function registers, Program status word; Power control, Stack operation, Hardware features—Parallel ports, Serial ports, Timer and counter, Interrupts, External memory interfacing; Addressing modes, Instruction set, Useful assembly language programs using instructions of 8051, Serial communication, 8051 interfacing RS 232, LED/LCD display, keyboard, Stepper motor.
3. Basic idea on Arduino.

Course Outcome (COs):

On the successful completion of this course, students will acquire knowledge on:

- Basic principles of microprocessor and microcontroller.

- Writing programs for microprocessor and microcontroller.
- Interfacing techniques for microprocessor and microcontroller.

Recommended Books

1. Douglas V. Hall – *Microprocessors and Interfacing: Programming and Hardware*
2. Ramesh S. Gaonkar – *Microprocessor Architecture, Programming and Applications with the 8085/8086*
3. A. K. Ray & K. M. Bhurchandi – *Advanced Microprocessors and Peripherals*
4. Muhammad Ali Mazidi, Janice Gillispie Mazidi & Rolin D. McKinlay – *The 8051 Microcontroller and Embedded Systems*
5. Kenneth J. Ayala – *The 8051 Microcontroller: Architecture, Programming and Applications*
6. Barry B. Brey – *The Intel Microprocessors: Architecture, Programming and Interfacing*
7. Simon Monk – *Programming Arduino: Getting Started with Sketches*
8. Michael J. Pont – *Embedded C for Microcontrollers*
- 9.

Paper: ELCC406X9

Computational Skill with Python (Practical), FM: 25, Credit: 02

1. Introduction to Python : Python Interpreter, syntax, keywords, variables, data types. Operators (arithmetic, relational, logical, assignment). Simple I/O (keyboard input, formatted output). Practical: programs for arithmetic operations, type conversion, and simple expressions.
2. Control Structures & Functions Lectures: Conditional statements (if, if-else, nested), Loops (for, while), break, continue, pass, Functions: definition, arguments, return values, default arguments, Practical: factorial, prime check, Fibonacci sequence, Armstrong number.
3. Strings and Lists in Python Strings: slicing, comparison, string operations, traversal. Lists: creation, indexing, operations, membership, nested lists, Practical: string palindrome, word count, list sorting/searching, matrix addition.
4. Applications & Problem Solving: Use of Python libraries (math, random).File handling basics (read/write text files).Practical Applications: Numerical integration using trapezoidal rule, Solve quadratic equation, Simple data analysis with lists (mean, max, min). Plot simple functions using.

Course Outcome (COs)

After completing this course the students will acquire knowledge on the following subject

- To acquire programming skills in core Python.
- To acquire object oriented skills in Python.
- To develop the skill of designing graphical user interfaces in Python.

- To develop the ability to write database applications in Python.

Recommended Books:

1. Mark Lutz – *Learning Python*
2. Allen B. Downey – *Think Python: How to Think Like a Computer Scientist*
3. Eric Matthes – *Python Crash Course: A Hands-On, Project-Based Introduction to Programming*
4. John V. Guttag – *Introduction to Computation and Programming Using Python*
5. Reema Thareja – *Python Programming: Using Problem Solving Approach*
6. Tony Gaddis – *Starting Out with Python*
7. Kenneth A. Lambert – *Fundamentals of Python: First Programs*
8. Paul Barry – *Head First Python*

Paper: ELCC407X0

Network Theory (Theory), FM 25, Credit 2, Lecture period: 20 Hours

1. Introduction to network analysis: T - π Transformation, Network theorems: Superposition, Thevenin, Norton and Maximum Power Transfer Theorems, Network elements, Network graphs, Nodal and Mesh analysis.
2. Two-port Network Parameters: Z, Y, ABCD and h parameters.
3. State variable method of circuit analysis, AC circuit analysis, Transient analysis,
4. Network functions, Driving point impedance and Transfer functions, Zero and Poles, Conditions for practical realization of network functions.
5. Filters: Passive filters, Constant K and m-derived filters: low pass, high pass, band pass and band reject filters.
6. Introduction to network simulation software LT-SPICE, Basic ideas to design and simulate the network circuit, Simple problems using SPICE.

Course Outcome (COs)

After completion of this course students will be able to:

- Acquire fundamental knowledge on network theorems, Network topology, Two-port network, Filters,
- Knowledge on Time and frequency response, Network functions.
- Develop problem solving skills on network analysis.

Recommended Books:

1. William H. Hayt Jr., Jack E. Kemmerly & Steven M. Durbin – *Engineering Circuit Analysis*
2. M. E. Van Valkenburg – *Network Analysis*
3. Charles K. Alexander & Matthew N. O. Sadiku – *Fundamentals of Electric Circuits*

4. Franklin F. Kuo – *Network Analysis and Synthesis*
5. A. Sudhakar & Shyammoan S. Palli – *Circuits and Networks: Analysis and Synthesis*
6. C. L. Wadhwa – *Network Analysis and Synthesis*
7. Thomas L. Floyd – *Electric Circuit Fundamentals*
8. Paul W. Tuinenga – *SPICE: A Guide to Circuit Simulation and Analysis Using PSp*

Paper: ELCO408VC

Indian Knowledge System (Theory), FM: 25, Credit: 02, Lecture period: 20 Hours

1. Science and Technology:
 - a. Development of Science in Ancient India: Astronomy, Mathematics, Engineering, and Medicine.
 - b. Metallurgy: Use of Copper, Bronze, and Iron in Ancient India.
 - c. Geography: Geography in Ancient India. Environmental conservation.
2. Indian Economy: History of the Indian Economy, Modern Economy.
3. Science and Technology in Modern India: Development of research organizations like CSIR, ISRO, DRDO, ICMR, ICAR, and Atomic Energy Commission. Launch of satellite.
4. Scientists of Modern India: Srinivas Ramanujan, C.V. Raman, Jagdish Chandra Bose, Homi Jehangir Bhabha, P.C. Mahalanobis, Meghnad Saha, Satyendra Nath Bose, HarGobind Khurana, Subrahmanyam Chandrasekhar, Venkatraman Ramakrishnan, Prafulla Chandra Roy, Sisir Kumar Mitra, Upendra Kishore Brahamachari.

Course Outcome:

- To make the students familiar with the Knowledge generated by Indians of the ancient past.
- To make the students familiar with the Knowledge of Science and technology in modern India.
- To make the students familiar with Scientists of Modern India.

Recommended Books:

1. Bipan Chandra – *India Since Independence*
2. Romila Thapar – *Early India: From the Origins to AD 1300*
3. A. L. Basham – *The Wonder That Was India*
4. B. V. Subbarayappa – *Science in India: A Historical Perspective*
5. Deepak Kumar – *Science and the Raj: A Study of British India*
6. V. K. Jain – *Science and Technology in Ancient India*
7. Bipan Chandra, Mridula Mukherjee & Aditya Mukherjee – *India's Struggle for Independence*
8. Government of India (NCERT) – *Science and Technology in India*

Paper: ELCO409NC
Vidyasagar: Life and Philosophy
(Compulsory Non-Credit Course)

Paper: ELCC451X1
Semiconductor Device (Theory), FM: 25, Credit: 02, Lecture Period: 20 hours

1. Review of Semiconductors: Energy Band in solids, Density of states, Fermi function, Carrier concentration, Current Transport, continuity equation, Generation and Recombination. Degenerate and Non degenerate semiconductor, Compound Semiconductor. PN Junction: Energy band diagram, Depletion region, Barrier potential, depletion width and depletion capacitance, abrupt junction, current voltage characteristics, equivalent circuit, Shockley equation, Diffusion capacitance, Heterojunction, Breakdowns in diodes, Zener diode, Tunnel diode, Varactor and Charge Storage diode.
2. Metal Semiconductor Contact: Concept of Barrier height and Schottky Effect, Thermionic emission theory, Ohmic contact,
3. Transistors fundamentals: Ebers-Moll Model, Cut-off Frequency, Microwave Transistor, Power Transistor and Switching Transistor.
4. Field Effect Transistors: JFET and MESFET, Basic characteristics and Derivation of drain Current, MOS capacitor, energy band diagrams, accumulation, flat band, mid band, depletion, inversion, LFCV and HFCV plots, MOSFET, Derivation of IV through gradual channel approximation, Short Channel Effects, High electron Mobility Transistor (HEMT),
5. Semiconductor Lasers: Photo Diodes, PIN photodiodes, Avalanche photodiodes (APD), Solar cells, I-V characteristics, fill factor and efficiency, LED, LCD and flexible display devices.

Course Outcome (CO)

After completion of this course, the students will be able to:

- Acquire fundamental knowledge on P-N junction diode, Schottky diode, BJT, FET, MESFET
- MOSFET etc. along with the high power and high frequency performances.
- Understand the PNP power devices.

Recommended Books:

1. S. M. Sze & Kwok K. Ng – *Physics of Semiconductor Devices*
2. Ben G. Streetman & Sanjay Kumar Banerjee – *Solid State Electronic Devices*
3. Donald A. Neamen – *Semiconductor Physics and Devices: Basic Principles*
4. Robert F. Pierret – *Semiconductor Device Fundamentals*
5. Jasprit Singh – *Semiconductor Devices: Basic Principles*
6. Karl Hess – *Advanced Theory of Semiconductor Devices*

7. Pallab Bhattacharya – *Semiconductor Optoelectronic Devices*
8. Mark Fox – *Optical Properties of Solids*

Paper: ELCC451X8
Semiconductor Device (Practical), FM: 25, Credit: 02

1. Measurement of resistivity of a Silicon/Germanium wafer using four probe methods and to determine its band gap.
2. Determination of carrier concentration, mobility of a semiconductor sample using Hall measurements.
3. Determination of the barrier height of a metal-semiconductor junction.
4. Determination of the Curie temperature of Barium Titanate.
5. Determination ideality factor and reverse saturation current of a P-N junction diode.
6. Determination of carrier concentration of the N-type semiconductor of a P⁺N junction using C-V measurement.
7. Study of current-voltage and Transfer Characteristics of a Junction Field Effect Transistor.
8. Simulation of current –voltage characteristics of a MESFET using TCAD.
9. Determination of energy band gap of the semiconductor of a P-N junction using temperature sensitive junction voltage measurement.
10. Study of the operational characteristics of (i) SCR (ii) DIAC (iii) TRIAC

Course Outcome (COs):

After completion of this course students will be able to:

- Acquire hands on experience on the fundamental techniques such as Hall measurement, conductivity measurement using four-probe method, C-V measurement of a P-N junction,
- measurement of barrier height of a Schottky contact etc.
- Understand the device modeling techniques using IC.
- Study the operational characteristics of SCR, DIAC, TRIAC etc.

Recommended Books:

1. S. O. Kasap – *Principles of Electronic Materials and Devices*
2. Donald A. Neamen – *Semiconductor Physics and Devices: Basic Principles*
3. Ben G. Streetman & Sanjay Kumar Banerjee – *Solid State Electronic Devices*
4. S. M. Sze & Kwok K. Ng – *Physics of Semiconductor Devices*
5. B. G. Streetman – *Solid State Electronic Devices*
6. S. Chattopadhyay & P. C. Rakshit – *Solid State Electronic Devices and Circuits Laboratory Manual*
7. A. K. Sawhney & Puneet Sawhney – *A Course in Electrical and Electronic Measurements and Instrumentation*
8. David K. Schroder – *Semiconductor Material and Device Characterization*

Paper: ELCC452X0
Signals and Systems (Theory), FM: 25, Credit: 02, Lecture Period: 20 hours

1. Signal Fundamentals: Definition and classification of analog, discrete-time and digital signals; time-domain and frequency-domain representations; periodic and aperiodic signals; energy and power signals; deterministic and non-deterministic signals; orthogonality of signal functions; signal space analogy; shifting, scaling and inversion of signals; Discretization of continuous-time signals; sampling process and basic idea of Nyquist sampling theorem; introduction to quantization and encoding.
2. Sequences and Basic Transform Tools: Classification of discrete-time sequences with respect to length, symmetry, periodicity, energy and power; generation of elementary sequences; arithmetic operations on sequences; basis functions; generalized Fourier series; Fourier transform of useful functions; properties of Fourier transform including linearity, shift and scaling.
3. Convolution, Correlation and Spectral Quantities: Graphical and analytical convolution; cross-correlation and autocorrelation; energy spectral density and power spectral density; essential bandwidth; relationship between time-domain characteristics and spectral properties.
4. Fundamentals of LTI Systems: Characteristics of Linear Time-Invariant systems; convolution as a system operation; concepts of stability and causality; FIR and IIR system basics.

Course Outcomes (COs)

After completion of this course students will be able to:

- Understand and classify different types of analog and discrete signals.
- Apply Fourier tools to analyse signals in time and frequency domains.
- Evaluate convolution, correlation, ESD, PSD and bandwidth-related quantities.
- Analyse the behaviour of basic LTI systems using time-domain methods.

Recommended Books:

1. Alan V. Oppenheim, Alan S. Willsky & S. Hamid Nawab – *Signals and Systems*
2. Simon Haykin & Barry Van Veen – *Signals and Systems*
3. B. P. Lathi – *Linear Systems and Signals*
4. Hwei P. Hsu – *Signals and Systems*
5. Charles L. Phillips, John M. Parr & Eve A. Riskin – *Signals, Systems and Transforms*
6. M. J. Roberts – *Signals and Systems: Analysis Using Transform Methods and MATLAB*
7. S. Salivahanan & C. Gnanapriya – *Signals and Systems*
8. P. Ramesh Babu & R. Anandanatarajan – *Signals and Systems*

Paper: ELCC453X9
Microprocessor and Microcontroller (Practical), Full Marks: 25, Credit: 02

1. Assembly language programs for arithmetic operations (Addition, Subtraction, Multiplication, Division, Code-conversion etc.) with 8086 processor.
2. Interfacing of switches and LEDs, Seven-segment displays, ADC and DAC with 8086 processor.

3. Interfacing of stepper motor with 8051 microcontroller.
4. Experiments with Arduino -- UART communication using two Arduino boards, Reception of a FM signal with Zigbee interface and displaying it in a serial monitor.

Course Outcome (COs):

At the end of this course, students will be:

- Confident to write programs for microprocessor and microcontroller.
- Successful to interface peripheral devices with microprocessor and microcontroller.
- Confident to solve problems with Arduino.

Recommended Books:

1. Douglas V. Hall – *Microprocessors and Interfacing: Programming and Hardware*
2. A. K. Ray & K. M. Bhurchandi – *Advanced Microprocessors and Peripherals: Architecture, Programming and Interfacing*
3. Kenneth J. Ayala – *The 8086 Microprocessor: Programming and Interfacing the PC*
4. Muhammad Ali Mazidi, Janice Gillispie Mazidi & Rolin D. McKinlay – *The 8051 Microcontroller and Embedded Systems*
5. N. Senthil Kumar, M. Saravanan, S. Jeevananthan & S. Shah – *Microprocessors and Interfacing*
6. Atul P. Godse & Deepali A. Godse – *Microprocessors and Microcontrollers*
7. Simon Monk – *Programming Arduino: Getting Started with Sketches*
8. Michael Margolis – *Arduino Cookbook*

Paper: ELCC454X0

E.M. Theory (Theory), FM: 25, Credit: 02, Lecture Period: 20 Hours

1. Review of Electromagnetism: Frequency bands. The equation of continuity for time varying fields, Inconsistency of Amperes Law, Maxwell's Equations, Conditions at Boundary Interface. Wave propagation in free space, dielectric medium and conducting medium. Dielectric and Conductor. Skin depth. Reflection of wave by perfect conductor- normal and oblique incidence (Horizontal and Vertical Polarization). Poynting theorem, Poynting vector, Flow of power.
2. Transmission Line: Types of Transmission Line. Telegrapher's equation. Transmission Line Theory, Loss less transmission line, Terminated transmission line, Distortion less line Voltage step up Transformer. Impedance matching, Quarter wave transformer, Stub matching, Smith Chart and its applications. Transients in transmission lines.
3. Guided Waves: Waves between parallel planes, TE modes, TM modes and TEM modes.
4. Wave Guides: Rectangular and Circular Wave Guide, Solutions of wave equation, TM and TE modes in rectangular wave guide. Power transmission and losses in wave guide. Characteristics of wave guide. Excitation of modes in wave guides.

5. Radiation: Potential functions and Electromagnetic field. Alternating current element, Hertzian dipole, Radiation from quarter wave monopole or half wave dipole.
6. Radio Wave propagation: Ground waves, Space wave, line of sight distance. Concept of Plasma, Ionosphere and its characteristics, reflection and refraction of radio waves in ionosphere, critical frequency, skip distance, Maximum useable frequency, fading, secant law, duct propagation.

Course Outcome (COs)

At the end of this course students will:

- Acquire knowledge on electrostatics, magnetostatics, electromagnetic theory.
- Develop basic ideas on transmission line, wave guides, radiation theory and antenna.
- Develop fundamental ideas on radio wave propagation.

Recommended Books:

1. Matthew N. O. Sadiku – *Elements of Electromagnetics*
2. R Shevgaonkar -Electromagnetic Waves
3. David K. Cheng – *Field and Wave Electromagnetics*
4. William H. Hayt Jr. & John A. Buck – *Engineering Electromagnetics*
5. John D. Kraus & Daniel A. Fleisch – *Electromagnetics with Applications*
6. Constantine A. Balanis – *Advanced Engineering Electromagnetics*
7. E. C. Jordan & K. G. Balmain – *Electromagnetic Waves and Radiating Systems*
8. Umesh Sinha – *Electromagnetic Waves and Radiating Systems*

Paper: ELCC455X0

Numerical Analysis (Theory), Full Marks: 25, Credit: 2 Lecture Period: 20 hours

1. Numerical Arithmetic :Representation of integers and real numbers; floating point representation and operators; IEEE floating point standards; absolute and relative error; error propagation; stability and ill-conditioning; order of approximation; truncation error.
2. Numerical Differentiation: Derivatives from divided difference table; central difference formula.
3. Numerical Integration: Trapezoidal rule; Newton–Cotes formulas.
4. Interpolation and Extrapolation: Lagrange polynomial; spline and rational function interpolation; extrapolation techniques.
5. Solution of Polynomial and Linear Systems: Gauss method; Gauss–Jordan method; ill-conditioned systems.
6. Ordinary Differential Equations: Runge–Kutta method; Adams–Moulton method; Adams–Bashforth method.

Course Outcomes (COs)

At the end of this course students will:

- Understand numerical arithmetic, error analysis, and floating-point computation.
- Apply numerical techniques for differentiation, integration, and interpolation.
- Solve polynomial and linear systems using standard numerical algorithms.
- Apply numerical methods to solve ordinary differential equations.

Recommended Books:

1. S. S. Sastry – *Introductory Methods of Numerical Analysis*
2. B. S. Grewal – *Numerical Methods in Engineering and Science*
3. Steven C. Chapra & Raymond P. Canale – *Numerical Methods for Engineers*
4. Richard L. Burden & J. Douglas Faires – *Numerical Analysis*
5. Kendall E. Atkinson – *An Introduction to Numerical Analysis*
6. Erwin Kreyszig – *Advanced Engineering Mathematics*
7. M. K. Jain, S. R. K. Iyengar & R. K. Jain – *Numerical Methods for Scientific and Engineering Computation*
8. C. F. Gerald & P. O. Wheatley – *Applied Numerical Analysis*

Paper: ELCC456X0

Electronic Materials (Theory), FM: 25, Credit: 02, Lecture Period: 20 hours

1. Introduction: Atomic structure and bonding, types of bindings, Classification of materials on bonding: conductors, semiconductors and insulators, imperfections in solids.
2. Electrical properties of materials: Conductivity, Fermi surface, electrical conduction in metal and alloys, conducting polymers and organic metals, ionic conduction in metal oxide, amorphous materials, superconductivity.
3. Dielectric properties of materials: Macroscopic electric field, dielectric constant and polarization, types of polarization, local field at an atom, temperature dependence on polarization, dielectric loss, ferroelectricity, anti-ferroelectricity, piezoelectricity.
4. Optical properties of materials: Index of refraction, damping constant, penetration depth, absorbance, reflectivity, transmissivity, electronic inter-band and intra-band transitions, photoluminescence and electroluminescence.
5. Magnetic properties of materials: Basic concepts, diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism and ferrimagnetism, influence of temperature on magnetic behaviour, soft and hard magnetic materials, magnetic storage.
6. Nanomaterials: Introductory concept of nanomaterials, low dimension structures: quantum well, wire and dots Graphene, carbon nanotube (CNT), metamaterial.

Course Outcome (COs):

After completion of this course, students will be able to:

- Acquire clear concepts on electronic behaviours of materials.

- Have basic to advanced knowledge of physics and chemistry of materials.
- Gain knowledge on mechanical, electrical, dielectric, optical and magnetic properties of materials.
- Understand the physics of superconductivity and nano-materials.
- Select proper materials for design and construction.

Recommended Books:

1. William D. Callister Jr. & David G. Rethwisch – *Materials Science and Engineering: An Introduction*
2. V. Raghavan – *Materials Science and Engineering*
3. Charles Kittel – *Introduction to Solid State Physics*
4. S. O. Kasap – *Principles of Electronic Materials and Devices*
5. Donald A. Neamen – *Semiconductor Physics and Devices*
6. J. I. Pankove – *Optical Processes in Semiconductors*
7. B. D. Cullity & C. D. Graham – *Introduction to Magnetic Materials*
8. C. N. R. Rao & A. Muller – *The Chemistry of Nanomaterials: Synthesis, Properties and Applications*

Paper: ELCC457X0

Applied Optics and Photonics (Theory), Credit: 2 Full Marks: 25, Lecture Hours: 20

1. Light–Matter Interaction and Perturbation Concepts: Time-independent and time-dependent perturbation concepts relevant to optical transitions; transition probability and physical meaning of Fermi’s Golden Rule in optical systems.
2. Optical Fiber Fundamentals : Principles of light propagation in optical media; ray model and wave model of fiber guidance; types of optical fibers; modal propagation; basic applications of optical fibers in communication.
3. Fiber Losses, Dispersion and Coupling : Attenuation mechanisms including absorption, scattering, micro-bending and macro-bending losses; Fresnel reflection; intermodal and intramodal dispersion; basic ideas of connectors, splices, alignment losses and directional couplers.
4. Optical Sources and Detectors : Light-emitting diodes and laser diodes; spontaneous and stimulated emission; internal quantum efficiency; radiation pattern and spectra; modulation characteristics; photoconductors, semiconductor photodiodes and phototransistors; noise concepts and basic optical link considerations.
5. Photonics, Optical Processing and Nonlinear Optics : Basic principles of optical multiplexing; concepts of WDM and TDM , Fiber Amplifiers, EDFA, DRA, WDM networks and components and Optical CDAMA; introduction to digital optics, optical logic operations and simple arithmetic circuits; nonlinear optical processes including harmonic generation, phase matching, frequency addition and subtraction.

Course Outcomes (COs)

After completion of this course, students will be able to:

- Understand fundamental light–matter interaction principles relevant to applied optics and photonics.
- Explain the structure, propagation characteristics and dispersion behaviour of optical fibers.
- Describe the working principles of LEDs, laser diodes and optical detectors.
- Apply optical concepts to multiplexing, optical processing and basic nonlinear optical phenomena.

Recommended Books:

1. Gerd Keiser – *Optical Fiber Communications*
2. John M. Senior & M. Yousif Jamro – *Optical Fiber Communications: Principles and Practice*
3. Govind P. Agrawal – *Fiber-Optic Communication Systems*
4. Bahaa E. A. Saleh & Malvin Carl Teich – *Fundamentals of Photonics*
5. Ajoy Ghatak & K. Thyagarajan – *Introduction to Fiber Optics*
6. Joseph C. Palais – *Fiber Optic Communications*
7. S. O. Kasap – *Optoelectronics and Photonics: Principles and Practices*
8. Robert W. Boyd – *Nonlinear Optics*

Paper: ELCC458X0

Control System (Theory), Full Marks 25, Credit: 02, Lecture Hours: 20

1. Introduction to Control Systems: Basic concepts of control systems; Open-loop and Closed-loop control systems; Advantages and disadvantages; Comparison between open-loop and closed-loop systems; Types of feedback control systems; Applications of control systems.
2. Transfer Function Representation: Concept of transfer function of linear time-invariant systems; Block diagram representation and block diagram reduction techniques; Signal flow graph; Mason's Gain Formula and its application.
3. Time Response Analysis: Standard test signals; Time response of first-order systems; Characteristic equation of feedback control systems; Transient response of second-order systems; Time-domain specifications; Steady-state response; Steady-state errors and error constants; P, PI and PID controllers; Tachometer.
4. Stability Analysis: Concept of stability; Routh–Hurwitz stability criterion; Root Locus Technique; Root locus concept and construction rules.
5. Frequency Response Analysis: Frequency response concepts; Bode plot; Gain margin and Phase margin; Stability analysis using Bode plots; Polar plots; Nyquist stability criterion and analysis.

Course Outcome (COs):

After completion of this course, students will be able to:

- Able to categorize different types of system and represent a complex control system model into a more simplified form by using block diagram reduction method, signal flow graph, Mason's gain formula
- Acquire knowledge to employ time domain analysis for transient analysis of the system for various standard input functions.
- Understand the stability of a control system using Routh's stability criterion, Root Locus technique, Bode plot and Nyquist plot.

Recommended Books:

1. Norman S. Nise – *Control Systems Engineering*
2. I. J. Nagrath & M. Gopal – *Control Systems Engineering*
3. Katsuhiko Ogata – *Modern Control Engineering*
4. B. C. Kuo & Farid Golnaraghi – *Automatic Control Systems*
5. K. Ogata – *Modern Control Engineering*
6. Richard C. Dorf & Robert H. Bishop – *Modern Control Systems*
7. S. Salivahanan & R. Rengaraj – *Control Systems Engineering*
8. Benjamin C. Kuo – *Automatic Control Systems*

Paper: ELCC459X0

Computer Network (Theory), Full Marks 25, Credit: 02, Lecture Hours: 20

1. Introduction to Computer Networks: Introduction to computer networks and data communication services; Roles of networks; Network topologies; Data transmission modes – Simplex, Half-duplex and Full-duplex; Reference models – OSI and TCP/IP.
2. Physical Layer and Switching Techniques: Functions of the physical layer; Communication media – guided and unguided, Synchronous and asynchronous data transmission; DTE and DCE; Switching techniques – circuit switching, packet switching and message switching; Multiplexing techniques; ISDN services; ATM networks.
3. Multiple access protocols – CSMA/CD; Wireless LAN protocols; IEEE standards
4. Network layer – internal organization; Routing algorithms; Hierarchical routing; Routing for mobile hosts; Congestion control algorithms; The network layer in the Internet; IP protocol-addressing and header format; Network devices – Repeater, Hub, Switch, Bridge, Router and Gateway.
5. TCP/IP Applications and Network Security: TCP/IP application protocols –Telnet, FTP, DNS, HTTP, SMTP, DHCP; Electronic mail; Email gateways; World Wide Web (WWW); Introduction to network security concepts.

Course Outcome (COs):

After completion of this course, the students will

- Develop basic ideas on data communications, network configurations, communication hardware and software.
- Develop basic knowledge on switching and transmission mechanism.
- Develop basic ideas on mobile communication network.

- Develop fundamental knowledge on network security.

Recommended Books:

1. Andrew S. Tanenbaum & David J. Wetherall – *Computer Networks*
2. Behrouz A. Forouzan – *Data Communications and Networking*
3. James F. Kurose & Keith W. Ross – *Computer Networking: A Top-Down Approach*
4. William Stallings – *Data and Computer Communications*
5. Larry L. Peterson & Bruce S. Davie – *Computer Networks: A Systems Approach*
6. Douglas E. Comer – *Internetworking with TCP/IP*
7. Natalia Olifer & Victor Olifer – *Computer Networks: Principles, Technologies and Protocols for Network Design*
8. Achyut S. Godbole & Atul Kahate – *Data Communications and Networks*

Paper: ELCO460X9, Full Marks 25, Credit: 02

Field Visit/ Industrial Visit

Paper: ELCO501X0

MOOCs FM: 50, Credit: 04

Paper: ELCC502X0

Microwave Technology (Theory), FM: 25, Credit: 02, Lecture Hours: 20

1. Introduction: Basic Microwave concepts, Microwave and millimetre wave frequencies.
2. Microwave Network: General approach to microwave circuit analysis, S parameters, Relation between S and Z parameters.
3. Cavity Resonators: Rectangular, Circular and Semicircular Cavity resonators, Q-factor.
4. Microwave Passive Circuits: Scattering matrix representation of microwave components, Attenuators and directional couples, Power divider, Faraday rotation, Isolator and Circulators, Microwave hybrid circuits, Wave guide tees (E-plane, H-plane, Magic tees and their S-matrix calculation), hybrid rings, Wave guide matching components, Inductive, Capacitive.
5. Microwave Tube: Microwave linear beam tubes, Klystrons, Reflex klystron, TWT, Microwave crossed field tubes: Magnetron.
6. Microwave Solid state devices: Microwave bipolar junction transistor, hetero-junction bipolar junction transistor. PIN diode, Tunnel diode, Transferred electron devices, Gunn diode, Avalanche multiplication diode, IMPATT diode, TRAPATT diode, BRITT diode.

7. RADAR Communication: Block diagram of Radar, Basic Principles, Radar Equation, Radar Cross section (RCS), RADAR losses, CW Radar, FMCW Radar, MTI and Pulsed Radar Principles, RADAR signal tracking and detection.

Course Outcomes (COs)

After successful completion of this course, the students will be able to:

- Understand and explain fundamental microwave and millimetre-wave concepts, frequency bands, and their significance in modern communication systems.
- Analyze microwave networks using scattering parameters and establish relationships between S-parameters and Z-parameters for microwave circuit characterization.
- Analyze the operation and performance of different cavity resonators (rectangular, circular, and semicircular) and evaluate parameters such as resonant frequency and quality factor (Q-factor).
- Design and analyze microwave passive components including attenuators, directional couplers, power dividers, waveguide tees, hybrid circuits, isolators, circulators, and matching components using scattering matrix representation.
- Explain the operating principles and applications of microwave vacuum tubes such as klystrons, reflex klystrons, TWTs, and magnetrons.
- Understand and compare the characteristics and applications of microwave solid-state devices including BJTs, HBTs, PIN diodes, Gunn diodes, IMPATT, TRAPATT, and other transferred-electron devices.
- Analyze RADAR systems by understanding radar principles, radar equations, RCS, losses, and different radar types such as CW, FMCW, MTI, and pulsed radar, along with signal detection and tracking techniques.

Recommended Books:

1. David M. Pozar – *Microwave Engineering*
2. Samuel Y. Liao – *Microwave Devices and Circuits*
3. R. E. Collin – *Foundations for Microwave Engineering*
4. Annapurna Das & Sisir K. Das – *Microwave Engineering*
5. Samuel Y. Liao – *Microwave Devices and Circuits*
6. K. C. Gupta – *Microwaves*
7. Merrill I. Skolnik – *Introduction to Radar Systems*
8. E. A. Guillemin – *Theory of Linear Physical Systems*

Paper: ELCC503X9

Communication and Microwave (Practical), FM: 25, Credit: 02

1. Generation and detection of AM signals and measurement of modulation index.
2. Generation and detection of FM signals and deviation measurement.
3. Study of envelope detector for AM signal.

4. Generation and characteristic study of Pulse Amplitude Modulation (PAM).
5. Generation and characteristic study of Pulse Width Modulation (PWM).
6. Study of the characteristics of LED.
7. Study of the characteristics of LDR.
8. Measurement of numerical aperture of an optical fiber.
9. Measurement of the dimension of a circular aperture using laser diffraction.
10. Study of pulse broadening in an optical fiber.
11. Study of reflex klystron characteristics.
12. Study of Gunn diode characteristics.
13. Reflection characteristics of an antenna measurement

Course Outcomes (COs)

Students completing this laboratory will be able to:

- Characterize optoelectronic sources and detectors.
- Measure optical fiber parameters and pulse distortion effects.
- Implement analog and digital modulation schemes.
- Perform microwave measurements.

Recommended Books:

1. George Kennedy and Bernard Davis – *Electronic Communication Systems*
2. Simon Haykin – *Communication Systems*
3. Wayne Tomasi – *Advanced Electronic Communication Systems*
4. Gerd Keiser – *Optical Fiber Communications*
5. John M. Senior – *Optical Fiber Communications: Principles and Practice*
6. John D. Kraus and Ronald J. Marhefka – *Antennas for All Applications*
7. K. D. Prasad – *Antennas and Wave Propagation*

Paper: ELCE504A0

Quantum Electronics (Theory), FM: 50, Credit: 04, Lecture Hours: 40

1. Foundations of Quantum Mechanics: Principles of quantum mechanics, Operators and observables, Schrödinger wave equation, Expectation values and eigenvalue problems, Bound-state applications: Particle in a box, Potential step and barrier, Harmonic oscillator

2. Perturbation Theory and Quantum Transitions: Time-independent perturbation theory, First-order corrections, Degenerate perturbation, Time-dependent perturbation theory, Transition probabilities, Fermi's Golden Rule and selection rules
3. Masers and Laser Fundamentals: Einstein coefficients, Absorption, spontaneous and stimulated emission, Population inversion, Two- and three-level systems, Working principle of MASER, Optical resonators and gain media.
4. Semiconductor and Quantum Lasers: Heterojunction lasers, Quantum well, wire and dot lasers, Multiple Quantum Well (MQW) lasers, Separate Confinement Heterostructure (SCH) lasers, GRINSCH lasers, Threshold current and optical confinement.
5. Superlattices and Avalanche Devices : Semiconductor superlattices, Quantum well APDs, Noise in APDs, Graded-gap APDs, SAM and staircase APDs, Solid-state photomultiplier tubes
6. Quantum Infrared Detectors: Quantum Well Infrared Photodetectors (QWIP), Intersubband transitions, Device structure, Performance parameters, Applications in thermal imaging and sensing,

Course Outcomes (COs)

On completion of the course, students will be able to:

- Solve bound-state quantum mechanical problems using the Schrödinger equation.
- Apply perturbation theory to analyze transition probabilities.
- Explain the principles of masers and laser action.
- Compare quantum well, wire, and dot laser structures.
- Analyze superlattices and avalanche photodiodes including noise mechanisms.
- Describe quantum well infrared photodetectors and related applications.

Recommended Books:

1. Nouredine Zettili – *Quantum Mechanics: Concepts and Applications*
2. David J. Griffiths and Darrell F. Schroeter – *Introduction to Quantum Mechanics*
3. H. Haken and H. C. Wolf – *The Physics of Atoms and Quanta*
4. Orazio Svelto – *Principles of Lasers*
5. Anthony E. Siegman – *Lasers*
6. B. E. A. Saleh and M. C. Teich – *Fundamentals of Photonics*
7. Pallab Bhattacharya – *Semiconductor Optoelectronic Devices*
8. Jasprit Singh – *Optoelectronics: An Introduction to Materials and Devices*
9. S. M. Sze and Kwok K. Ng – *Physics of Semiconductor Devices*
10. Bahaa E. A. Saleh and Malvin Carl Teich – *Fundamentals of Photonics*

Paper: ELCE504B0
RF and Antenna Design (Theory), FM: 50, Credit: 04, Lecture Hours: 40

1. Microwave Filters: Periodic structure, Filter design by image parameter and insertion loss methods. Filter Transformation.
2. Microwave Amplifier Design: Two port power gain, Single stage amplifier design, broadband amplifier, power amplifier.
3. RF Oscillator and Mixers: RF Oscillator, Microwave Oscillator, Microwave Mixers
4. Noise and active RF components: Noise in Microwave systems, Microwave Integrated Circuits.
5. Microwave Systems: Wireless communication systems: Friis Formula, Radio receiver architecture. Radio meter system.
6. Antenna array and synthesis: Linear arrays – Analysis of Linear arrays – Phased arrays – Binomial arrays – Pattern multiplication – Method of excitation of antennas – Impedance matching techniques. Synthesis methods: Schelkunhoff polynomial – Fourier transform – Woodward Lawson method.
7. Resonant Antennas: Wires and Patches, Dipole antenna, Yagi-Uda antennas, Micro-strip antenna
8. Broadband antennas: Traveling wave antennas Helical antennas, Biconical antennas, Sleeve antennas, and Principles of frequency independent antennas, Spiral antennas, and Log - periodic antennas.
9. Aperture antennas: Techniques for evaluating gain, Reflector Antennas-Parabolic reflector antenna principles, Axisymmetric parabolic reflector antenna, Offset parabolic reflectors, Dual reflector antennas, Gain calculations for reflector antennas, Feed antennas for reflectors, Field representations, Matching the feed to the reflector, General feed model, Feed antennas used in practice.

Course Outcomes (COs)

After successful completion of this course, the students will be able to:

- Analyze and design microwave filters using periodic structures, image parameter method, insertion loss method, and apply filter transformations for practical RF applications.
- Analyze two-port microwave amplifiers and design single-stage, broadband, and power amplifiers based on power gain and performance requirements.
- Understand and analyze the operating principles of RF and microwave oscillators and mixers used in modern RF communication systems.
- Evaluate noise performance in microwave systems and understand the characteristics and applications of active RF components and microwave integrated circuits (MICs).
- Analyze microwave and wireless communication systems using Friis transmission formula, radio receiver architectures, and radio meter systems.
- Analyze and synthesize antenna arrays including linear, phased, binomial arrays using pattern multiplication and various excitation and impedance matching techniques.
- Apply antenna synthesis techniques such as Schelkunoff polynomial method, Fourier transform method, and Woodward–Lawson method to achieve desired radiation characteristics.
- Understand the operating principles, radiation characteristics, and applications of resonant and broadband antennas including dipole, Yagi-Uda, microstrip, helical, log-periodic, and spiral antennas.

- Analyze aperture antennas and reflector antenna systems, including gain evaluation techniques, feed design, field representation, and practical implementation aspects.

Recommended Books:

1. David M. Pozar – *Microwave Engineering*
2. Robert E. Collin – *Foundations for Microwave Engineering*
3. Samuel Y. Liao – *Microwave Devices and Circuits*
4. G. S. N. Raju – *Microwave Engineering*
5. Constantine A. Balanis – *Antenna Theory: Analysis and Design*
6. John D. Kraus and Ronald J. Marhefka – *Antennas for All Applications*
7. Robert S. Elliott – *Antenna Theory and Design*
8. Kai Chang – *RF and Microwave Wireless Systems*
9. Guillermo Gonzalez – *Microwave Transistor Amplifiers: Analysis and Design*
10. Warren L. Stutzman and Gary A. Thiele – *Antenna Theory and Design*

Paper: ELCE504C0

Power and Industrial Electronics (Theory), FM: 50, Credit: 04, Lecture Hours: 40

1. Introduction: Silicon Controlled Rectifier (SCR), SCR construction, Two transistor analogy, Characteristics, Gate characteristics, Different types of SCR. Construction and characteristics of DIAC and TRIAC. Triggering Schemes: dv/dt , Thermal, Light and Gate Triggering, Gate triggering using R and RC firing circuits, firing circuit using UJT and 555 Timer, SCR protection.
2. Power Supplies: Block diagram of regulated power supply – A simple regulated transistorized power supply (circuit and working) – Principle and working of switch mode power supply (SMPS), EMC/EMI shielding. Principle and working of uninterrupted power supply (UPS).
3. DC and AC Motor Control: DC Motor, One Quadrant and Two Quadrant Single Phase SCR Drive for DC Motor, AC Motor, Speed Control Methods for Induction Motor, Cyclo converters. Non-Motor Industrial Applications; Resistance Welding, Induction Heating, Dielectric Heating.
4. Introduction to Electric Vehicle & Charging System: Non-dedicated & Dedicated EV Charging system, Lithium-ion Batteries, Lithium Polymer (LiPo) Battery, Charging types in EV Charger Station (CCS; CHAdeMO; GB/T), AC and DC Charging Technologies.
5. Power Converters for Lighting, pumping and refrigeration Systems: Electronic ballast, LED power drivers for indoor and outdoor applications. PFC based grid fed LED drivers, PV / battery fed LED drivers. PV fed power supplies for pumping/refrigeration Applications.

Course Outcomes (COs)

- After successful completion of this course, the students will be able to:
- Understand the concepts of power semiconductor devices and their triggering schemes
- Acquire a critical knowledge of various Electrical Instruments used in the Laboratory.
- Design the DC and AC motor drives for speed control.
- Analyze and design converters for lighting, HV systems and Bi-directional converters for charge /discharge applications

Recommended Books:

1. Muhammad H. Rashid – *Power Electronics: Circuits, Devices and Applications*
2. P. S. Bimbhra – *Power Electronics*
3. Ned Mohan, Tore M. Undeland and William P. Robbins – *Power Electronics: Converters, Applications and Design*
4. B. K. Bose – *Modern Power Electronics and AC Drives*
5. M. D. Singh and K. B. Khanchandani – *Power Electronics*
6. S. N. Singh – *Power Electronics*
7. C. L. Wadhwa – *Electrical Power Systems*
8. Iqbal Husain – *Electric and Hybrid Vehicles: Design Fundamentals*
9. James Larminie and John Lowry – *Electric Vehicle Technology Explained*
10. K. Billings – *Switchmode Power Supply Handbook*

Paper: ELCE505A0

Nano material & Characterization (Theory), FM: 50, Credit: 04, Lecture Hours: 40

1. Fundamentals: History of nanotechnology, Feynman's vision on nano-science and technology, Bulk vs nanomaterial, Clusters and magic numbers, Nanoscale architecture.
2. Classification: Classification based on dimensionality, Zero dimensional nanostructures: metal, semiconductor and oxide nanoparticles; One dimensional nanostructures: nanowires and nanorods; Two dimensional nanostructures: thin films, Three dimensional nanomaterials, Special nanomaterials: carbon fullerenes, carbon nanotube
3. Properties on size and shape: Size and shape dependent properties, Band structure of materials at nanoscale, Density of states of materials at nanoscale, Mechanical properties, Thermal properties, Optical properties, Magnetic properties, Electrical properties.
4. Synthesis: Different processes of synthesis of nanomaterials, Top-down and bottom-up approaches, Lithographic technique, Ball milling, Gas phase condensation, Vacuum deposition, Physical vapor deposition (PVD), Chemical vapor deposition (CVD), Colloidal methods, Molecular beam epitaxy (MBE), Metal organic chemical vapor deposition (MOCVD).
5. Characterization techniques: X-ray diffraction, Optical microscopy, Electron microscopy, Scanning electron microscopy (SEM), Scanning probe microscopy (SPM), Transmission electron microscopy (TEM), Atomic force microscopy (AFM), Scanning tunneling microscopy (STM), Energy dispersive x-ray (EDX) analysis, Differential scanning calorimetry, Nuclear magnetic resonance (NMR) method, Electrical probing to nanostructures, C-V measurement.

Course Outcomes (COs)

After successful completion of this course, the students will be able to:

- Understand the fundamentals of nanoscience and nanotechnology, including historical development, Feynman's vision, nanoscale architecture, and the differences between bulk and nanomaterials.
- Classify nanomaterials based on dimensionality and structure, and explain the characteristics of zero-, one-, two-, and three-dimensional nanostructures, including special nanomaterials such as carbon nanotubes, fullerenes, core-shell structures, and hybrid materials.
- Analyze the size- and shape-dependent properties of nanomaterials, including electronic band structure, density of states, mechanical, thermal, optical, magnetic, and electrical properties.
- Understand and compare various synthesis techniques of nanomaterials using top-down and bottom-up approaches, including lithography, ball milling, vapor deposition, gas phase, and chemical synthesis methods.
- Explain the principles and applications of major characterization techniques such as XRD, SEM, TEM, AFM, STM, EDX, DSC, NMR, and electrical probing methods for analyzing structural, morphological, thermal, and electrical properties of nanomaterials.

Recommended Books:

1. C. P. Poole Jr. and F. J. Owens – *Introduction to Nanotechnology*
2. Charles P. Poole Jr. – *Nanotechnology*
3. Bharat Bhushan – *Springer Handbook of Nanotechnology*
4. K. K. Chattopadhyay and A. N. Banerjee – *Introduction to Nanoscience and Nanotechnology*
5. T. Pradeep – *Nano: The Essentials – Understanding Nanoscience and Nanotechnology*
6. Guozhong Cao and Ying Wang – *Nanostructures and Nanomaterials: Synthesis, Properties and Applications*
7. Dieter Vollath – *Nanomaterials: An Introduction to Synthesis, Properties and Applications*
8. B. S. Murty, P. Shankar, B. Raj, B. B. Rath and J. Murday – *Textbook of Nanoscience and Nanotechnology*

Paper: ELCE505B0

Satellite & Mobile Communication (Theory), FM: 50, Credit: 04, Lecture Hours: 40

1. Introduction to Satellite Communication: Evolution and applications of satellite communication, basic concepts of satellite communication systems, satellite frequency bands (L, S, C, X, Ku, Ka), advantages and limitations of satellite communication, satellite orbits: GEO, MEO, LEO, HEO, Kepler's laws and orbital parameters, look angles and coverage area and satellite subsystems overview.
2. Satellite Communication Systems and Link Analysis: Satellite system block diagram, transponders: bent pipe and regenerative, uplink and downlink concepts, satellite link budget analysis, free space path loss, noise temperature and system noise, carrier-to-noise ratio (C/N) and performance analysis of satellite links.
3. Introduction to Mobile Communication: evolution of mobile communication systems, basic concepts of wireless communication, cellular concept and frequency reuse, cell splitting, sectoring, and

clustering, multiple access techniques: FDMA, TDMA, CDMA, handoff and roaming, capacity improvement techniques and interference management.

4. Mobile Radio Propagation and Channel Modeling: mobile radio propagation, mechanisms, large-scale path loss models, small-scale fading and multipath effects, Doppler effect and coherence time, delay spread and coherence bandwidth, shadowing and fading models, noise and interference in mobile systems and diversity techniques.
5. Modern Mobile Communication Systems: Overview of 2G systems (GSM architecture and features), introduction to 3G systems, Overview of 4G LTE systems, Introduction to 5G mobile communication, OFDM and MIMO concepts, satellite–mobile integrated communication, emerging trends in mobile and satellite communication, future challenges and applications.

Course Outcomes (COs)

After successful completion of this course, the students will be able to:

- Acquire knowledge of the evolution, applications, basic concepts, frequency bands, advantages, limitations, and subsystems of satellite communication systems.
- Acquire knowledge of satellite orbits (GEO, MEO, LEO, HEO), Kepler’s laws, orbital parameters, look angles, and coverage area analysis.
- Acquire knowledge of satellite communication system architecture, including transponders, uplink and downlink concepts, and satellite link budget analysis with performance evaluation.
- Acquire knowledge of mobile communication fundamentals such as cellular concepts, frequency reuse, multiple access techniques, handoff, roaming, capacity enhancement, and interference management
- Acquire knowledge of mobile radio propagation mechanisms, channel modeling, fading and shadowing effects, Doppler spread, delay spread, noise, interference, and diversity techniques.
- Acquire knowledge of modern mobile communication systems (2G, 3G, 4G LTE, and 5G), along with OFDM, MIMO, satellite–mobile integrated communication, emerging trends, future challenges, and applications.

Recommended Books:

1. Timothy Pratt, Charles W. Bostian and Jeremy E. Allnutt – *Satellite Communications*
2. Dennis Roddy – *Satellite Communications*
3. Wilbur L. Pritchard, Robert A. Nelson and Henri G. Suyderhoud – *Satellite Communication Systems Engineering*
4. Theodore S. Rappaport – *Wireless Communications: Principles and Practice*
5. William C. Y. Lee – *Mobile Cellular Telecommunications: Analog and Digital Systems*
6. Jochen Schiller – *Mobile Communications*
7. Andrea Goldsmith – *Wireless Communications*
8. Vijay K. Garg – *Wireless Communications and Networking*
9. Mischa Schwartz – *Mobile Wireless Communications*
10. Simon Haykin and Michael Moher – *Modern Wireless Communications*

Paper: ELCE505C0

Network Security and Cryptography (Theory), FM: 50, Credit: 04, Lecture Hours: 40

1. Introduction to Network Security: Security concepts and goals; security attacks—passive and active attacks; security services and security mechanisms; OSI security architecture; cyber threats and vulnerabilities; risk assessment and security policy basics.
2. Classical Cryptography: Principles of cryptography; classical encryption techniques—substitution and transposition ciphers; Caesar cipher, Playfair cipher, Hill cipher, Vigenère cipher; cryptanalysis methods; brute-force attacks and frequency analysis.
3. Symmetric Key Cryptography: Symmetric encryption techniques; block ciphers and stream ciphers; Data Encryption Standard (DES); Advanced Encryption Standard (AES); modes of operation; key distribution methods; strengths and limitations of symmetric key cryptography.
4. Asymmetric Cryptography and Key Management: Public key cryptography principles; RSA algorithm; Diffie–Hellman key exchange; Elliptic Curve Cryptography (ECC); digital certificates; Public Key Infrastructure (PKI); key management issues.
5. Authentication, Integrity and Network Security Protocols: Cryptographic hash functions—MD5 and SHA; message authentication codes (MAC); digital signatures; authentication protocols; Secure Sockets Layer (SSL) and Transport Layer Security (TLS); IP Security (IPsec); firewalls and intrusion detection systems (IDS).

Course Outcomes (COs):

After completing this course, students will be able to:

- Explain security attacks and defense mechanisms
- Apply classical and modern cryptographic techniques
- Analyze symmetric and asymmetric encryption algorithms
- Understand authentication, integrity, and secure communication protocols

Recommended Books:

1. William Stallings – *Cryptography and Network Security: Principles and Practice*
2. Behrouz A. Forouzan – *Cryptography and Network Security*
3. Charlie Kaufman, Radia Perlman and Mike Speciner – *Network Security: Private Communication in a Public World*
4. Bruce Schneier – *Applied Cryptography*
5. Atul Kahate – *Cryptography and Network Security*
6. Bernard Menezes – *Network Security and Cryptography*
7. Douglas R. Stinson and Maura Paterson – *Cryptography: Theory and Practice*
8. Mark Stamp – *Information Security: Principles and Practice*

Paper: ELCC506X1

VLSI Technology (Theory), FM: 25, Credit: 02, Lecture Hours: 20

1. Introduction to VLSI: Historical perspective, Understanding of SSI, MSI, LSI, VLSI and ULSI; Types of integrated circuits, VLSI design methodologies, VLSI design flow, Design hierarchy, Concept of regularities, modularity and locality; VLSI design styles.
2. MOS transistor: The metal-oxide semiconductor (MOS) structure, MOS system under external bias, Structure and operation of MOS field effect transistor (MOSFET), MOSFET current-voltage characteristics, MOSFET scaling and small-geometry effects, MOSFET capacitance.
3. Fabrication technology: Fabrication facilities: pure water system, clean room; Crystal growth and wafer preparation; Oxidation: Growth mechanism and kinetics, Thin oxide, Oxide quality; Diffusion: Basic diffusion process, Diffusion equation, Diffusion profiles, Intrinsic and extrinsic diffusions, Lateral diffusion; Ion implantation: Mechanism, System, Advantages, Ion distribution, Ion channeling, Implant damage, Annealing; Film formation: Dielectric, Poly-silicon, Metal; Lithography: Optical lithography, Masks, Photoresist, Pattern transfer, Resist stripping, Next-generation lithographic techniques; Etching: Wet and dry etching, Etching of: Silicon, Silicon dioxide, Silicon nitride, Poly-silicon and Aluminum films; Layout design rules: Micron and lambda based design rules; MOSIS, Stick diagram, VLSI process integration: Bipolar transistor, MOS, CMOS, Bi-CMOS, Silicon on insulator (SOI), Fin-FET technology; Packaging: Package types, Package design considerations.
4. MOS inverter and its characteristics: Introduction: Voltage transfer characteristic (VTC), Noise immunity and noise margins, Power and area considerations; CMOS inverter.
5. Digital CMOS logic design: Logic level standards, Fan-in and Fan-out, Digital logic design, CMOS design methodology, Design of CMOS- inverter, NAND and NOR gates, Pseudo-NMOS logic, CMOS transmission gate, Domino CMOS logic, Pass transistor logic.

Course Outcomes (COs)

After successful completion of this course, the students will be able to:

- Understand the evolution of integrated circuits from SSI to ULSI and explain VLSI design methodologies, design flow, hierarchy, regularity, modularity, and different VLSI design styles.
- Explain the structure, operation, and electrical characteristics of MOS transistors, including MOSFET scaling, small-geometry effects, and capacitance behavior.
- Understand semiconductor fabrication processes and technologies, including oxidation, diffusion, ion implantation, lithography, etching, film deposition, layout design rules, and advanced process integrations such as CMOS, Bi-CMOS, SOI, and FinFET.
- Analyze the operation and performance of MOS and CMOS inverters with respect to voltage transfer characteristics, noise margins, power consumption, and area considerations.
- Design and analyze digital CMOS logic circuits such as inverters, NAND, NOR, transmission gates, pseudo-NMOS, pass transistor logic, and domino logic using standard CMOS design methodologies.

Recommended Books:

1. Neil H. E. Weste & David Harris – *CMOS VLSI Design: A Circuits and Systems Perspective*
2. Jan M. Rabaey, Anantha Chandrakasan & Borivoje Nikolic – *Digital Integrated Circuits: A Design Perspective*
3. Sung-Mo Kang & Yusuf Leblebici – *CMOS Digital Integrated Circuits: Analysis and Design*
4. Wayne Wolf – *Modern VLSI Design: System-on-Chip Design*
5. S. M. Sze & Kwok K. Ng – *Physics of Semiconductor Devices*
6. Sorab K. Ghandhi – *VLSI Fabrication Principles: Silicon and Gallium Arsenide*
7. Stephen A. Campbell – *The Science and Engineering of Microelectronic Fabrication*
8. Douglas A. Pucknell & Kamran Eshraghian – *Basic VLSI Design*

Paper: ELCC506X8

VLSI Technology (Practical), FM: 25, Credit: 02

1. SPICE based experiments

- To study schematic diagram of MOS inverter with different loads.
- To study schematic diagram of two input NAND gate.
- To study schematic diagram of two input NOR gate.
- To study schematic diagram of different logic circuits.

2. Layout Based experiments

- Draw layout of CMOS inverter
- Draw layout of two input NAND gate.
- Draw layout of two input NOR gate.
- Draw layout of any logic circuit.

3. VHDL/Verilog based experiments

- Implement and simulate half adder, full adder, half subtractor and full subtractor circuit.
- Implement and simulate multiplexer.
- Implement and simulate decoder circuit.
- Implement and simulate magnitude comparator circuit.
- Implement and simulate flip-flop.
- Implement and simulate counter circuit.

Course Outcomes (COs)

After successful completion of this course, the students will be able to:

- Understand and analyze the schematic design of basic CMOS digital circuits such as MOS inverters, NAND, NOR, and other logic gates using SPICE simulation tools.
- Evaluate the functionality and performance of CMOS logic circuits through schematic-level simulation and interpretation of voltage transfer characteristics and logic behavior.
- Design and develop layout of basic CMOS circuits including inverter, NAND, NOR, and other logic circuits following layout design rules.
- Apply layout-based design techniques to realize CMOS logic circuits and understand the relationship between schematic and physical implementation.
- Implement and simulate fundamental digital building blocks such as adders, subtractors, multiplexers, decoders, comparators, flip-flops, and counters using VHDL/Verilog.
- Analyze simulation results of HDL-based digital circuits to verify functional correctness and timing behavior.

Recommended Books:

1. Neil H. E. Weste & David Harris – *CMOS VLSI Design: A Circuits and Systems Perspective*
2. Sung-Mo Kang & Yusuf Leblebici – *CMOS Digital Integrated Circuits: Analysis and Design*
3. Douglas A. Pucknell & Kamran Eshraghian – *Basic VLSI Design*
4. Samir Palnitkar – *Verilog HDL: A Guide to Digital Design and Synthesis*
5. Douglas L. Perry – *VHDL: Programming by Example*
6. Stephen Brown & Zvonko Vranesic – *Fundamentals of Digital Logic with VHDL Design*
7. Jan M. Rabaey, Anantha Chandrakasan & Borivoje Nikolic – *Digital Integrated Circuits: A Design Perspective*
8. Paul Horowitz & Winfield Hill – *The Art of Electronics*

Paper: ELCO507X9

Social Service/ Community Engagement (NSS/Outreach)

FM:25, Credit: 02

Paper: ELCE551A0

System Design through Verilog (Theory), FM: 50, Credit: 04, Lecture Hours: 40

1. Introduction to Verilog: Need for HDL and overview of Verilog, Verilog program structure, Verilog operators (arithmetic, logical, relational, bitwise), Verilog modules and module instantiation, Verilog ports (input, output, inout), data types (wire, reg, parameter), continuous and procedural assignments, basics of gate-level modelling
2. Gate level modelling: Half adder and full adder, ripple carry adder, parallel adder, comparator, decoder and encoder, multiplexer and demultiplexer, Verilog modeling of ROM, review of flip-flops, Verilog modeling of flip-flops (SR, JK, D, T)

3. Switch level modelling: Introduction to switch-level modelling, MOS switches and primitives, modeling of CMOS gates, modeling of Boolean functions using CMOS, transistor-level modeling of logic gates, CMOS delay times, Rise time and fall time, Signal strengths and charge storage modelling.
4. Dataflow and behavioural modelling: Basics of dataflow modelling, assign statements and operators, examples of dataflow modelling, adders, comparators, multiplexers, procedural blocks (always, initial), blocking and non-blocking assignments, conditional statements (if-else, case), looping statements, introduction to sequential logic in Verilog, Clocked behavioral modelling, Verilog modeling of: Counters (up, down, mod-n), Shift registers (SISO, SIPO, PISO, PIPO) and Sequence detectors (Moore and Mealy machines)
5. Test Benches and verifications: Introduction to test benches, components of a Verilog test bench, stimulus generation, monitoring and display tasks, test benches for: combinational circuit, Sequential circuits, arithmetic and logic unit (ALU).

Course Outcome (CO):

After completing this course, students will be able to:

- Understand the need for Hardware Description Languages (HDLs) and describe the structure, syntax, operators, data types, ports, and basic constructs of Verilog for digital system design.
- Acquire knowledge about design and implementation of gate-level models in Verilog for basic combinational and sequential circuits such as adders, comparators, encoders/decoders, multiplexers/demultiplexers, ROMs, and flip-flops.
- Can analyse and develop switch-level models using MOS primitives to implement CMOS logic gates and Boolean functions, and evaluate timing parameters such as rise time, fall time, delay, and signal strengths.
- Acquire knowledge about dataflow and behavioural modeling techniques to design combinational and sequential digital systems including counters, shift registers, and finite state machines (Moore and Mealy sequence detectors).

Recommended Books:

1. Samir Palnitkar – *Verilog HDL: A Guide to Digital Design and Synthesis*
2. Zainalabedin Navabi – *Verilog Digital System Design*
3. Michael D. Ciletti – *Advanced Digital Design with the Verilog HDL*
4. J. Bhasker – *A Verilog HDL Primer*
5. Stephen Brown and Zvonko Vranesic – *Fundamentals of Digital Logic with Verilog Design*
6. Thomas and Moorby – *The Verilog Hardware Description Language*
7. Sunggu Lee – *Digital System Design Using Verilog*
8. Donald D. Givone – *Digital Principles and Design with Verilog HDL*

Paper: ELCE551B0
Optical Communication (Theory), FM: 50, Credit: 04, Lecture Hours: 40

1. Optical Fiber Fundamentals: Basic principles of light propagation, types of optical fiber, applications of optical fiber in communication and advantages, modal propagation – ray model and wave model.
2. Attenuation and Dispersion in Optical Fibers: Attenuation mechanisms, material dispersion, intermodal and intramodal dispersion, absorption and scattering losses, micro-bending and macro-bending radiation losses, connectors and splices, misalignment losses, optical directional coupler.
3. Optical Sources: LEDs and Lasers: LEDs and direct band-gap semiconductors, spontaneous emission, device structures, internal quantum efficiency, radiation pattern and spectra, modulation characteristics and transient response. Lasers: stimulated emission, laser structures, radiation pattern and spectra, narrow-linewidth lasers, threshold current and temperature sensitivity, turn-on delay, gas lasers and semiconductor lasers.
4. Pulse Coding and Multiplexing: Pulse coding principles, time-division multiplexing and de-multiplexing (TDM), wavelength-division multiplexing and de-multiplexing (WDM).
5. Optical Receivers and Networks: Photoconductors, semiconductor photodiodes, phototransistors, noise sources, optical link design, power penalty, SONET/SDH, DWDM systems, optical switches, fiber amplifiers – EDFA and Raman amplifiers.
6. Laser-Based Communication and LiDAR: Channel-based and channel-less laser communication systems, principles of LiDAR.
7. Non-linear Optics: Non-linearity of optical media, second and higher harmonic generation, phase-matching condition, frequency addition and subtraction.

Course Outcomes

Students completing this course will be able to:

- Explain light propagation mechanisms in optical fibers.
- Analyze attenuation, dispersion and optical link design issues.
- Describe LEDs, lasers and photodetectors used in optical systems.
- Understand multiplexing techniques and photonic networks.
- Discuss nonlinear optical effects and LiDAR applications.
- Outline concepts of nonlinear optics.

Recommended Books:

1. Gerd Keiser – *Optical Fiber Communications*
2. John M. Senior – *Optical Fiber Communications: Principles and Practice*
3. Govind P. Agrawal – *Fiber-Optic Communication Systems*
4. Joseph C. Palais – *Fiber Optic Communications*
5. B. E. A. Saleh and M. C. Teich – *Fundamentals of Photonics*
6. Ajoy Ghatak and K. Thyagarajan – *Introduction to Fiber Optics*
7. J. Gowar – *Optical Communication Systems*
8. G. P. Agrawal – *Nonlinear Fiber Optics*

Paper: ELCE551C0
IOT & Internet Technology (Theory), FM: 50, Credit: 04, Lecture Hours: 40

1. Introduction: Internet architecture, Access point and Internet Service Provider, Domain
2. Internet Connectivity: Dial up, ISDN, DSL, T1, E1, T3, E3, SONET, Wireless Layered Model of Internet: OSI, TCP/IP, Client-server
3. Protocols in the Application layer: FTP, Electronic Mail, World Wide Web, HTTP, URL, WAP
4. Language of the Web: Hypertext Markup Language including the concepts of Hyperlinks, Inline Images, HTML Forms, Common Gateway Interface
5. Introduction to IoT: applications, Sensing and Actuation, IoT Devices and deployment models
6. IoT Networking: basic IoT components, interdependencies, service oriented architecture
7. IoT Data Protocols: MQTT, SMQTT, CoAP, XMPP, AMQP
8. IoT Communication Protocols: IEEE 802.15.4, ZigBee, Bluetooth low energy (BLE), Wi-Fi for IoT communications.
9. Interoperability in IoT: Low power Interoperability for IPV6 IoT
10. Industrial IoT (IIoT): Industrial IoT and its benefits, Examples from Sensor body-area network, Smart cities and Smart homes, Agriculture

Course Outcomes (COs)

After successful completion of this course, the students will be able to:

- Explain the fundamentals of Internet architecture, including the roles of access points, Internet Service Providers (ISPs), and the Domain Name System (DNS).
- Compare different Internet connectivity technologies such as Dial-up, ISDN, DSL, leased lines, SONET, and wireless networks, and relate them to the OSI and TCP/IP layered models and the client–server architecture.
- Describe the working principles and use cases of application-layer Internet protocols including FTP, Electronic Mail, HTTP, WWW, URL, and WAP.
- Develop basic web pages using HTML by applying concepts of hyperlinks, inline images, forms, and understanding the role of CGI in web applications.
- Identify the core concepts of the Internet of Things (IoT), including sensing, actuation, IoT devices, deployment models, and real-world applications.
- Explain IoT networking architecture, basic components, interdependencies, and service-oriented architecture used in IoT systems.
- Analyze IoT data communication protocols such as MQTT, SMQTT, CoAP, XMPP, and AMQP with respect to efficiency, reliability, and application suitability.
- Distinguish between various IoT communication protocols including IEEE 802.15.4, ZigBee, BLE, and Wi-Fi, and select appropriate technologies for IoT applications.

- Understand interoperability challenges in IoT and explain low-power IPv6-based solutions for seamless IoT integration.
- Illustrate the concepts and benefits of Industrial IoT (IIoT) through applications in smart cities, smart homes, agriculture, and sensor-based networks.

Recommended Books:

1. Behrouz A. Forouzan – *Data Communications and Networking*
2. Douglas E. Comer – *The Internet Book: Everything You Need to Know about Computer Networking and How the Internet Works*
3. Kurose and Ross – *Computer Networking: A Top-Down Approach*
4. Raj Kamal – *Internet of Things: Architecture and Design Principles*
5. Arshdeep Bahga and Vijay Madisetti – *Internet of Things: A Hands-On Approach*
6. Samuel Greengard – *The Internet of Things*
7. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry – *IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things*
8. Olivier Hersent, David Boswarthick and Omar Elloumi – *The Internet of Things: Key Applications and Protocols*

Paper: ELCE551D0

Industrial Instrumentation (Theory), FM: 50, Credit: 04, Lecture Hours: 40

1. Introduction to Instruments: Types of Industrial Instruments, Static and Dynamic characteristics of Instrument, Sensor linearization techniques, redundant measurement systems.
2. Transducers: Classification of transducers, Selection of transducers, Resistive, capacitive & inductive transducers, Resistive and capacitive touch screen transducer used in mobiles, Displacement transducer-LVDT, Piezoelectric transducer, Photo transducer, Digital transducer, Fibre optic sensors.
3. Measurement of position, displacement, velocity, acceleration: Limit switch, Proximity Sensors - Inductive, Photoelectric, Capacitive and Magnetic. Shaft encoders, Tachometers. Accelerometers.
4. Force and Torque measurement systems: Strain gauge, strain gauge signal processing, Load cells: column, shear and bending beam type. Introduction to industrial weighing systems and beltconveyor weighing systems. Principle of torque measurement in rotating shafts.
5. Biomedical Instruments: Basic operating principles and uses of (i) Clinical thermometer (ii) Stethoscope (iii) Sphygmomanometer (iv) ECG machine (v) Radiography (vi) Ophthalmoscope (vii) Ultrasound scanning (viii) Pulse oxymeter (ix) Glucometer, Basic ideas of CT scan and MRI scan.

Course Outcome:

- Understand the concepts of operating principle of sensors used to measure position,
- displacement, velocity and acceleration.

- Acquire a critical knowledge of operating principle of force and torque measurement systems
- Learn the construction, operational principles of various biomedical instruments.

Recommended Books:

1. A. K. Sawhney and Puneet Sawhney – *A Course in Electrical and Electronic Measurements and Instrumentation*
2. Ernest O. Doebelin and Dhanesh N. Manik – *Measurement Systems: Application and Design*
3. D. Patranabis – *Sensors and Transducers*
4. H. S. Kalsi – *Electronic Instrumentation*
5. S. Tumanski – *Principles of Electrical Measurement*
6. John G. Webster – *Medical Instrumentation: Application and Design*
7. Leslie Cromwell, Fred J. Weibell and Erich A. Pfeiffer – *Biomedical Instrumentation and Measurements*
8. Jacob Fraden – *Handbook of Modern Sensors: Physics, Designs, and Applications*

Paper: ELCE552A0

Semiconductor Packaging and Testing(Theory), FM: 50, Credit: 04, Lecture Hours: 40

1. Overview of electronic systems packaging: Introduction and Objectives of the course definition of a system and history of semiconductors, Products and levels of packaging, Packaging aspects of handheld products, Case studies in the application.
2. Semiconductor Packaging Overview: Basics of Semiconductor and Process flowchart; Video on“Sand-to-Silicon”, Wafer fabrication, inspection and testing, Wafer packaging; Packaging evolution, Chip connection choices, Wire bonding, TAB and flipchip-1, TAB and flipchip-2, Need for packaging & Single chip packages or modules (SCM), Commonly used packages and advanced packages, Materials in packages, Thermal mismatch in packages, Current trends in packaging, Multichip modules (MCM)-type, System-in- package (SIP), Packaging roadmaps, Hybrid circuits.
3. Electrical Design considerations in systems packaging (L. Umanand): Electrical Issues–I Resistive Parasitic, Electrical Issues–II; Capacitive and Inductive Parasitic, Electrical Issues–III; Layout guidelines and the Reflection problem, Electrical Issues – IV; Interconnection, CAD for Printed Wiring Boards: Benefits from CAD; Introduction to DFM, DFR & DFT, Components of a CAD package and its highlights, Design Flow considerations; Beginning a circuit design with schematic work and component layout, Demo and examples of layout and routing; Technology file generation from CAD; DFM checklist and design rules; Design for Reliability.
4. Printed Wiring Board Technologies: Board-level packaging aspects, Review of CAD output files for PCB fabrication, Photo plotting, and mask generation, Process flow-chart; Vias; PWB substrates, Surface preparation, Photoresist and application methods, UV exposure and developing, Printing technologies for PWBs, PWB etching, Resist stripping, Screen-printing technology, Through-hole manufacture process steps, Panel and pattern plating methods, Solder mask for PWBs, Multilayer PWBs; Introduction to microvias, Microvia technology, and Sequential build-up technology process flow for high-density interconnects, Conventional Vs HDI technologies; Flexible circuits.

5. Surface Mount Technology: SMD benefits; Design issues; Introduction to soldering, Reflow, and Wave Soldering methods to attach SMDs, Solders: Wetting of solders; Flux and its properties, Defects in wave soldering, Vapor phase soldering, BGA soldering, and desoldering/Repair, SMT failures, SMT failure library, Tin Whiskers, Tin-lead, and lead-free solders; Phase diagrams, Thermal profiles for reflow soldering, Lead-free alloys, Lead-free solder considerations; Green electronics; RoHS compliance and e-waste recycling issues
6. Thermal Design considerations in systems packaging: Introduction to embedded passives: Need for embedded passives, Design Library, Embedded resistor processes, Embedded capacitors; Processes for embedding capacitors.

Course Outcomes (COs)

After successful completion of this course, the students will be able to:

- Understand the fundamentals of electronic systems packaging, including levels of packaging, evolution of semiconductor technology, and packaging requirements for modern electronic and handheld products.
- Explain semiconductor packaging processes from wafer fabrication to final packaging, and compare different chip interconnection techniques such as wire bonding, TAB, and flip-chip for single-chip and multi-chip modules.
- Analyze electrical design issues in system packaging, including resistive, capacitive, and inductive parasitics, interconnection effects, signal integrity, and reflection problems, using appropriate layout guidelines.
- Apply CAD tools and design methodologies for printed wiring board (PWB) design, incorporating DFM, DFR, and DFT principles, layout and routing strategies, and design-for-reliability considerations.
- Understand printed wiring board manufacturing technologies, including fabrication processes, multilayer PWBs, microvia and HDI technologies, flexible circuits, and comparison of conventional and advanced PCB technologies.
- Analyze surface mount technology (SMT) processes, soldering techniques, solder materials, defect mechanisms, reliability issues, and compliance with lead-free, RoHS, and green electronics requirements.
- Understand thermal and advanced packaging considerations, including thermal mismatch effects, current packaging trends, system-in-package concepts, and the role of embedded passives in modern electronic systems.

Recommended Books:

1. Rao R. Tummala – *Fundamentals of Microsystems Packaging*
2. Rao R. Tummala – *Microelectronics Packaging Handbook*
3. John H. Lau – *Chip on Board: Technology for Multichip Modules*
4. Clyde F. Coombs Jr. – *Printed Circuits Handbook*
5. Lee W. Ritchey – *Right the First Time: A Practical Handbook on High-Speed PCB and System Design*
6. L. Umanand – *Power Electronics: Essentials and Applications*
7. Ray Prasad – *Surface Mount Technology: Principles and Practice*
8. John H. Lau – *Advanced MEMS Packaging*

Paper: ELCE552B0
Radar Signal & Processing(Theory), FM: 50, Credit: 04, Lecture Hours: 40

1. Introduction: Radar frequency, Radar Application
2. Basic Radar parameters: Range, cross range, minimum range, unambiguous range, pulse repetition frequency, Pulse integration, Radar cross section, Radar range equation, Doppler effect in Radar, Range resolution
3. Classification by sources: CW Radar, FM-CW Radar, Pulsed Radar
4. Classification by function: Search Radar, Tracking Radar, Imaging Radar
5. Radar Hardware: Transmitter, Receiver, Duplexer, Display
6. Radar Measurement Fundamentals: Clutter, Noise, Statistical characterisation of
7. Detection Performance: probability of detection, probability of false alarm, Albershei Equation, Fluctuating target models: Swerling 0-5
8. Modern Radar Signal Processing tools for better Measurements: MTI filter for clutter rejection, CFAR Techniques, Monopulse Tracking, Improvement in Range resolution by pulse compression, Improvement in cross range resolution by Synthetic Aperture technique, Improved 2D and 3D imaging strategies.

Course Outcomes (COs)

After successful completion of this course, the students will be able to:

- Explain radar fundamentals, operating frequency bands, and major radar applications in civilian and defense systems.
- Analyze basic radar parameters such as range, cross-range, resolution, radar cross section, Doppler effect, and pulse characteristics using the radar range equation.
- Classify radar systems based on source and function, and compare the operating principles of CW, FM-CW, pulsed, search, tracking, and imaging radars.
- Describe the architecture and working of radar hardware components including transmitter, receiver, duplexer, and display units.
- Understand radar measurement fundamentals by explaining the effects of noise and clutter and their statistical characterization in radar systems.
- Evaluate radar detection performance using probability of detection, probability of false alarm, Albersheim equation, and fluctuating target models (Swerling cases).
- Apply modern radar signal processing techniques such as MTI filtering, CFAR detection, monopulse tracking, pulse compression, and synthetic aperture radar (SAR) for performance enhancement.
- Explain advanced radar imaging strategies for improved 2D and 3D target representation and high-resolution measurements.

Recommended Books:

1. Merrill I. Skolnik – *Introduction to Radar Systems*
2. Merrill I. Skolnik – *Radar Handbook*
3. Mark A. Richards – *Fundamentals of Radar Signal Processing*
4. Nadav Levanon and Eli Mozeson – *Radar Signals*
5. Byron Edde – *Radar Principles, Technology, Applications*
6. Peyton Z. Peebles Jr. – *Radar Principles*
7. Eugene F. Knott, John F. Schaeffer and Michael T. Tulley – *Radar Cross Section*
8. George W. Stimson – *Introduction to Airborne Radar*

Paper: ELCE552C0

Embedded System (Theory), FM: 50, Credit: 04, Lecture Hours: 40

1. Introduction: Overview of the Embedded System, Microprocessors vs Micro controller, Harvard V/s Von-Neumann Processor/Controller Architecture, PWM generator, Data Converters (ADC, DAC), Introduction to advance communication protocol
2. Introduction to microcontrollers: Overview of architecture of a typical microcontroller such as AVR microcontroller (Arduino Uno, Different pin configuration, Introduction to the Arduino IDE (Integrated Development Environment), General Structure of an Arduino Code, Interfacing Sensors with Microcontroller, Sampling Aspect
3. RTWA for Embedded Systems: Introduction, Timers, Counters and Watchdog Timers, UART, Pulse Width Modulators, Stepper Motor Controllers, Analog – to – Digital Converters, and Real Time Clocks.
4. Typical embedded system: Elements of embedded systems, general purpose and domain specific processor, Memory interfacing: Memory technologies – SRAM, DRAM and ROM, different types of ROM- PROM, EPROM, EEPROM, memory interfacing circuits, single cycle versus multiple cycle interfacing, timing diagrams, etc.,
5. Sensors & Actuators: IR, humidity, PIR (passive infrared), ultrasonic, piezoelectric, smoke sensors, Stepper Motor, Piezo Buzzer.
6. Interfacing: Understanding Serial Peripheral Interface (SPI), Inter-Integrated Circuits (I2C), RS-232C Serial Interface, Universal Serial Bus (USB), Infrared communication (IrDA), Bluetooth
7. Embedded system design methodologies: Design flow, Sensors Types, Performance Characteristics (Justification for selection), Device Considerations, Size of the Hardware, voltagescaling, Energy calculation, Processing Power. Experiments: Dual LED blinking with PWM output, Reading RTD (Resistive Temperature Detector)
8. Application of Embedded Systems: Automatic Blood Pressure Monitoring; Digital Stethoscope, Airbag Deployment Systems Vehicle Ride and control suspension system.

Course Outcomes (COs)

After successful completion of this course, the students will be able to:

- Understand and design the embedded systems
- Understand types of memory and interfacing to external world
- Understand the various types of communication interfaces
- Understand the challenges of Embedded systems.
- Understand RTWA for embedded system
- Understand different types of market available embedded system

Recommended Books:

1. Raj Kamal – *Embedded Systems: Architecture, Programming and Design*
2. Frank Vahid and Tony Givargis – *Embedded System Design: A Unified Hardware/Software Introduction*
3. Shibu K. V. – *Introduction to Embedded Systems*
4. Muhammad Ali Mazidi, Sarmad Naimi and Sepehr Naimi – *The AVR Microcontroller and Embedded Systems Using Assembly and C*
5. Simon Monk – *Programming Arduino: Getting Started with Sketches*
6. Michael J. Pont – *Embedded C*
7. David E. Simon – *An Embedded Software Primer*
8. Jonathan W. Valvano – *Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers*

Paper: ELCE552D0

Optimization, Machine Learning and AI (Theory), FM: 50, Credit: 04, Lecture Hours: 40

1. Optimization: Functions of a single variable, maxima and minima, optimization involving a single variable, gradient search algorithms: steepest descent, conjugate gradient descent
2. Machine Learning and AI:
 - (i) Supervised Learning: regression and classification problems, simple linear regression, multiple linear regression, k-nearest neighbour, naive Bayes classifier, linear discriminant analysis, decision trees, cross-validation methods such as leave-one-out (LOO) cross-validation, k-folds cross-validation, multi-layer perceptron, feed-forward neural network;
 - (ii) Unsupervised Learning: clustering algorithms, k-means/k-medoid, hierarchical clustering, top-down, bottom-up: single-linkage, multiple-linkage, dimensionality reduction, principal component analysis.

Course Outcomes (COs)

- After completing this course, students will be able to:
- Apply optimization techniques to engineering and data-driven problems
- Understand and implement core Machine Learning algorithms
- Analyze AI problem-solving strategies and intelligent agents
- Select appropriate ML/AI techniques for real-world applications m.

Recommended Books:

1. Christopher M. Bishop – *Pattern Recognition and Machine Learning*
2. Tom M. Mitchell – *Machine Learning*
3. Kevin P. Murphy – *Machine Learning: A Probabilistic Perspective*
4. Ethem Alpaydin – *Introduction to Machine Learning*
5. Stuart Russell and Peter Norvig – *Artificial Intelligence: A Modern Approach*
6. Stephen Marsland – *Machine Learning: An Algorithmic Perspective*
7. S. S. Rao – *Engineering Optimization: Theory and Practice*
8. Kalyanmoy Deb – *Optimization for Engineering Design*

Paper: ELCC553X9

Research Project / Dissertation FM: 100, Credit: 08

Paper: ELCC554X9

Internship/ Applied Field and Industry Project/ Start Up proposal and Practice FM: 50, Credit: 04

Paper: ELCO555X0

IPR FM: 25, Credit: 02, Lecture hours : 20

1. Introduction to Intellectual Property Rights: Meaning, nature, and characteristics of Intellectual Property, Historical development of IPR, Rationale and theories of IPR (Natural Rights Theory, Utilitarian Theory, Incentive Theory, and Economic Theory), Importance of IPR in scientific research and innovation
2. International and Indian IP Framework: Role of WIPO, WTO and TRIPS Agreement, Paris Convention and Berne Convention, Overview of Indian IP Laws: (Patents Act, 1970 (as amended), Copyright Act, 1957 and Trade Marks Act, 1999, Role of IP offices in India)
3. Patents – Concept and Principles: Meaning and objectives of patents, Criteria for patentability: (Novelty, Inventive Step and Industrial Applicability), Patentable and non-patentable subject matter, Rights of patent holder, Term of patent and Compulsory licensing (concept only)

4. Copyrights and Trademarks: Copyright(Subject matter of copyright, Economic and moral rights, and Ownership and duration) and Trademark:(Concept and functions of trademarks, Distinctiveness and classification, and Rights conferred by registration)
5. Other Forms of IPR and Enforcement: Geographical Indications, Industrial Designs, Trade Secrets, Infringement and remedies, Civil and criminal remedies, and IPR and ethical issues in research

Course Outcomes (COs)

After completion of the course, students will be able to:

- Explain theoretical foundations of IPR.
- Identify different types of intellectual property.
- Understand patentability criteria and legal principles.
- Recognize the importance of IPR in scientific innovation.
- Demonstrate awareness of enforcement mechanisms and ethical issues.

Recommended Books:

1. N. S. Gopalakrishnan and T. G. Agitha – *Principles of Intellectual Property*
2. P. Narayanan – *Intellectual Property Law*
3. V. K. Ahuja – *Law Relating to Intellectual Property Rights*
4. W. R. Cornish, David Llewelyn and Tanya Aplin – *Intellectual Property: Patents, Copyright, Trade Marks and Allied Rights*
5. S. K. Verma and Raman Mittal – *Intellectual Property Rights: A Global Vision*
6. Deborah E. Bouchoux – *Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets*
7. World Intellectual Property Organization (WIPO) – *Understanding Intellectual Property*
8. Prabuddha Ganguli – *Intellectual Property Rights: Unleashing the Knowledge Economy*

Or / Hardware Maintenance