Vidyasagar University

Midnapore-721102, West Bengal

The SYLLABUS for

POST-GRADUATE Programme

in

ELECTRONICS

Under Choice Based Credit System (CBCS)

(Semester Programme)

[w.e.f. 2022-23]

Preamble

Electronics is a modern subject of learning. Phenomenological changes are happening in society with the advancement of electronics. It is imperative to have skilled manpower to accelerate the progress in our society. In this direction, the M.Sc. in Electronics course at Vidyasagar University is designed to impart basic as well as advanced 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 serving 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 the Choice Bases Credit System (CBCS) with the contents of modern technological aspects of electronics. It is regularly updated to impart contemporary knowledge to students in the field of electronics. The curriculum is framed up with courses like Materials science, Semiconductor devices, Optoelectronics, VLSI design and technology, Microwave engineering etc. The Students get hands-on exposure in technologically modern laboratories like the 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. In 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 classroom teaching regularly. Apart from the regular classes for the students, remedial classes are arranged for the weaker students. Coaching classes are also provided for NET, SET, and GATE examinations. Special lectures, Invited talks, and Seminars are arranged for the students regularly in the department.

Programme/Learning Outcome (P/LO)

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

1. Acquire strong mathematical foundation, computational skills with Python, knowledge of 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.
2. Confident to work independently in circuit design lab, digital lab, microprocessor and microcontroller lab, communication lab and VLSI design lab.
3. Learn to identify and formulate a research problem, literature review, scientific methodology, inference drawing, report writing and public presentation.
4. Expose to the industrial atmosphere and to work therein with a real problem.

5. Learn ethical principles, professional ethics, responsibilities and engineering practice norms.
6. Train up for individual and teamwork.
7. Fit for doing work at different research organizations, Government and multi-national sectors.
8. Set up a mind to serve society and to do good for the nation.

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:

1. State-of-the-art knowledge about various theoretical and experimental techniques that are used within the scope of this subject.
2. 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.
3. 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.
4. 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.
5. Skills to compete in national/international level examinations such as NET/SET/GATE etc., and can pursue a career in higher studies.
6. Confident to do work at various research institutes, public and private organizations.

COURSE STRUCTURE OF M.Sc. in ELECTRONICS
VIDYASAGAR UNIVERSITY

SEMESTER	COURSE NO.	COURSE TITLE	FULL MARKS	No of Lectures (hours)	CREDIT (L-T-P)
I	ELC 101A	Mathematical Techniques	25	20	2(1-1-0)
	ELC 101B	Computational Techniques	25	20	2(1-1-0)
	ELC 102A	Electronic Materials	25	20	2(1-1-0)
	ELC 102B	Electronic Devices	25	20	2(1-1-0)
	ELC 103	Network Analysis and Synthesis	50	40	4(3-1-0)
	ELC 104	Analog Electronics	50	40	4(3-1-0)
	ELC 195	Computational Skill with Python	50	40	4(0-0-8)
	ELC 196	Analog Circuit Laboratory	50	40	4(0-0-8)
	TOTAL		300	240	24
II	ELC 201	Electromagnetism and Antenna	50	40	4(3-1-0)
	ELC 202	Signals and Systems	50	40	4(3-1-0)
	ELC 203	Digital System Design	50	40	4(3-1-0)
	C-ELC 204A	E-waste	25	20	2(1-1-0)
	C-ELC 204B	Renewable Energy	25	20	2(1-1-0)
	ELC 295	Digital Circuit Laboratory	50	40	4(0-0-8)
	ELC 296	Semiconductor Device Lab	50	40	4(0-0-8)
	TOTAL		300	240	24
III	ELC 301	Electronic Communication	50	40	4(3-1-0)
	ELC 302	VLSI Design and Technology	50	40	4(3-1-0)
	ELC 303	Control System and Instrumentation	50	40	4(3-1-0)
	C-ELC 304	Introduction to Electronics	50	40	4(3-1-0)
	ELC 395	Electronic and Optical Communication Lab	50	40	4(0-0-8)
	ELC 396	VLSI Design Lab	50	40	4(0-0-8)
	TOTAL		300	240	24
IV	ELC 401	Microprocessor and Microcontrollers	50	40	4(3-1-0)
	ELC 402	Digital Signal Processing	50	40	4(3-1-0)
	ELC 403	Elective –I / MOOCS Courses	50	40	4(3-1-0)
	ELC 404	Elective –II / MOOCS Courses	50	40	4(3-1-0)
	ELC 495	Microprocessor and Microcontrollers Lab	50	40	4(0-0-8)
	ELC 496	Project/Internship	50	40	4(0-0-8)
	TOTAL		300	240	24
ALL TOTAL			1200		96

The total mark is 1200 and the total credit is 96.

Elective Papers	
Elective-I: ELC 403	**Elective-II: ELC 404**
ELC 403A: RF and Microwave Systems ELC 403B: Renewable Energy ELC 403C: Power and Industrial Electronics	ELC 404A: Optical Communication and Photonic Devices ELC 404B: Nanomaterials and Characterizations ELC 404C: Computer Network and Security

Distinctive features of course content:			
Feature	***Course Code***	***Course Wise Percentage of such courses****	***Programme-wise percentage of courses#***
Value-added course:	ELC 101B	100	12.5
	ELC 195	100	
	ELC 102B	100	
	ELC 401	100	
Employability/entrepreneurship/ skill development:	ELC 302	100	20.83
	ELC 402	100	
	ELC 403	100	
	ELC 404	100	
	ELC 496	100	
Digital Content:	ELC 195	100	8.33
	ELC 396	100	
Ethics, gender, human values, environment & sustainability:	ELC 204A	100	4.17
	ELC 204B	100	
New course introduced:	ELC 402	100	12.5
	ELC 403	100	
	ELC 404	100	

SEMESTER –I

Paper-ELC 101 : Mathematical Methods and Computational Techniques
Full Marks: 50. Credit: 4

ELC 101A: Mathematical Techniques
Full Marks: 25, Credit: 02

1. Vector spaces and matrices: n-dimensional Vector spaces, inner product, Schmidt's orthogonalisation, Schwarz and Bessel inequality. *3 h*
2. Hermitian and unitary matrices: eigenvectors and eigenvalues, diagonalization, unitary transformation. Cayley Hamilton theorem. *4 h*
3. Integral transforms: Laplace transform: Properties of Laplace transform, Inversion formula, Convolution, Application to ordinary and partial differential equations; Fourier transform: Properties of Fourier transform, Inversion formula, Convolution, Parseval's relation, Application to ordinary and partial differential equations. *4 h*
4. Special Functions**:** Legendre Equation: Generating function, Legendre functions of the first kind and second kind, orthogonal properties, Rodrigue's formula, Bessel Equation: Bessel function, Series solution of Bessel equation, Recurrence relations. *4 h*
5. Complex variables**:** Function of a complex variable, Limit, Continuity, Differentiability, the definition of an analytic function, Cauchy-Riemann equation, construction of analytic function, complex integration, Jordan arc, Cauchy's theorem, Cauchy's integral formula, More's theorem, Liouville's theorem, Taylor's and Laurent's series. *5 h*

ELC 101B: Computational Techniques
Full Marks: 25, Credit : 02

1. Numerical arithmetic: Representation of integers, real numbers, floating point representation, floating point operators, IEEE standards of floating point numbers, Absolute and relative error, Error propagation, stability and ill conditioning, Order of approximation, Truncation error. *5 h*
2. Numerical differentiation: Derivatives from divided difference table, central difference formula. *3 h*
3. Numerical integration: Trapezoidal rule, Newton-Cotes formula. *2 h*
4. Interpolation and extrapolation: Lagrange Polynomial, spline and rational function, interpolation and extrapolation. *3 h*
5. Solving of polynomial equation: Gauss and Gauss-Jordan methods, III conditioned systems. *3 h*
6. Ordinary differential equation: Runge-Kutta method, Adams-Moulton, Adams-Bash forth method. *4 h*

Course outcome (CO)

After completion of this course students will be able to:

- Understand the different mathematical methods and their applications.
- Understand numerical arithmetic and various numerical techniques to solve different problems through numerical computation.

Paper: ELC102 Electronic Materials and Devices

Full Marks: 50, Credit: 4

ELC102A: Electronic Materials

Full Marks: 25, Credit: 02

1. Introduction: Atomic structure and bonding, types of bindings, Classification of materials on bonding: conductors, semiconductors and insulators, imperfections in solids. *3h*
2. Electrical properties of materials: Conductivity, reflection and absorption, Fermi surface, electrical conduction in metal and alloys, conducting polymers and organic metals, ionic conduction in metal oxide, amorphous materials, superconductivity. *4h*
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. *3h*
4. Optical properties of materials**:** Index of refraction, damping constant, penetration depth, absorbance, reflectivity, transmissivity, electronic inter-band and intra-band transitions, optical properties and band structure , photoluminescence and electroluminescence. *3h*
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. *3h*
6. Nanomaterials**:** Introductory concept of nanomaterials, low dimension structures: quantum well, wire and dots Graphene, carbon nanotube (CNT), metamaterial. *4h*

Course Outcome (CO):

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.

ELC102B: Electronic Devices

Full Marks: 25, Credit : 02

7. 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. *6h*

7. Metal Semiconductor Contact**:** Concept of Barrier height and Schottky Effect, Thermionic emission theory, Ohmic contact, *2h*
8. Transistors fundamentals: Ebers-Moll Model, Cut-off Frequency, Microwave Transistor, Power Transistor and Switching Transistor. *3h*
9. 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), *6h*
10. Semiconductor Lasers**:** Photo Diodes, PIN photodiodes, Avalanche photodiodes (APD), Solar cells, I-V characteristics, fill factor and efficiency, LED, LCD and flexible display devices. *3h*

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 PNPN power devices.

PAPER -ELC 103: Network Analysis and Synthesis

Full Marks: 50, Credit: 4

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. *6h*
2. Two-port Network Parameters: Z, Y, ABCD and h parameters. *4h*
3. State variable method of circuit analysis, AC circuit analysis, Transient analysis, *4h*
4. Network functions, Driving point impedance and Transfer functions, Zero and Poles, Conditions for practical realization of network functions. *4h*
5. Filters: Passive filters, Constant K and m-derived filters: low pass, high pass, band pass and band-reject filters. *4h*
6. Network Synthesis: Hurwitz Polynomials, Positive real functions, Condition for positive real functions for physical reliability. Testing procedure of positive real functions, Synthesis technique for one port passive network (Foster and Cauer form), Synthesis of two-port networks by ladder technique. *10h*
7. Introduction to network simulation software (SPICE), Basic ideas to design and simulate the network circuit, Simple problems using SPICE. *8h*

Course Outcome (CO)

After completion of this course students will be able to:

- Acquire fundamental knowledge on network theorems, Network topology, Two-port network, Filters, Time and frequency response, Network functions, Network analysis using Laplace transform etc.
- Understand Foster and Cauer methods of network synthesis.
- Develop problem solving skills on network analysis and synthesis.

PAPER - ELC-104: Analog Electronics

Full Marks: 50 Credit: 4

1. Review of Diode: Basics of diode, Ideal and linear piecewise models, applications of diode: rectifier, clipper clamper, voltage doubler**.** *2h*

2. BJT: BJT biasing, Stabilization, methods of stabilization, transfer characteristics of BJT, BJT acts as a switch and a amplifier, Modelling of BJT, small signal analysis of BJT, CB,CE and CC amplifiers, derivation of voltage gain, current gain, input impedance and output impedance, frequency response characteristics, lower and upper half frequencies, bandwidth. High frequency model of BJT, Miller's theorem, Darlington pair, cascade and cascade configurations, current mirror circuits. *10h*

3.MOSFET: MOSFET operation, Small signal and large signal model, NMOS, PMOS and CMOS inverter, MOSFET as a switch and an amplifier, MOS biasing, CS, CD, and CG amplifier using MOSFET. *8h*

4. Feedback Amplifiers: Feedback topologies, feedback amplifiers, determination of loop gain, stability of amplifier, Frequency compensation. Hartley, Colpitt's and Phase Shift oscillators. *6h*

5. OPAMP: Internal architecture OP-AMP, basics of op-amp, inverting and non inverting amplifier, summers, differentiators, integrators, active filters, Schmitt triggers OP-Amp as a Comparator, Schmitt triggers, Instrumentation Amplifiers, Logarithmic Amplifiers, Anti-log amplifiers, Multipliers, Divider, ramp generator, square and triangular wave generator. *10h*

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) *4h*

Course Outcome (CO)

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
- Acquire fundamental knowledge about PLL

Paper- ELC-195: Computational skill on Python (Practical)

Full Marks: 50 Credit: 4

Python Interpreter, Common Python Syntax, Python shell Types of Variables in Python, Identifiers and keywords, Using Operators and Operands, Strings, : I/O Input Used in Python ,Operators (Arithmetic operator, Relational operator, Logical or Boolean operator, Assignment, Operator, Ternary operator, Bit wise operator, Increment or Decrement operator) Input and Output Statements, Control statements (Branching, Looping, Conditional Statement, Exit function, Difference between break, continue and pass.), Defining Functions, default arguments, Errors and Exceptions, String as a compound data type, Length, Traversal and the for loop, String slices, String comparison, A find function, Looping and counting, List values, Accessing elements, List length, List membership, Lists and for loops, List operations, List deletion. Cloning lists, Nested lists

Write programs using Python

1. To Find factorial of an integer N where N may be read from the keyboard.
2. To Check a number N enter through keyboard is prime or non-prime.
3. To Calculate the first N Fibonacci numbers where N may be read from the keyboard.
4. To Check a number N enters through keyboard is Armstrong or not.
5. To Calculate the functions sin(x), cos(x) and exp(x) by representing each of them as an infinite series. Read in the value of the desired accuracy from the keyboard. Also find the numbers of terms calculated to achieve desire accuracy.
6. To find out the root of the Algebraic and Transcendental equations using Bisection, Regula-falsi, Newton Raphson and iterative methods.
7. To implement Newton's Forward and Backward Interpolation formula
8. To integrate numerically using Trapezoidal Rule, Simpson's Rules
9. To develop computer programms for solution of system of equations using Gauss Elimination Technique, Gauss-Seidel iterative method..
10. To find numerical solution of ordinary differential equations by Runge-Kutta method.

Course Outcome (CO)

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

Paper: ELC 196: Analog Circuit and Design laboratory (Practical)

Full Marks: 50, Credit: 4

1. To study fixed bias circuit of a BJT amplifier:
   To design a fixed bias transistorized amplifier and measure $V_{BE,}$ V_{CE}, V_{CB}, I_C, I_B, I_E 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 $V_{BE,}$ V_{CE}, V_{CB}, I_C, I_B, I_E 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 R_E.
   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.

7. a) To construct a regulated power supply using a power transistor as a pass element and an op-AMP as a comparator.
   b) Design of variable power supply using LM 317.
8. To design an active first and second order Butterworth filter and study its frequency response characteristics and find the cut-off frequencies.

9. To design of RC phase shift oscillator.

10. To design and Integrator and Differentiator using OP-AMP and draw the transfer characteristics.

Course Outcome (CO)

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

- To correlate the theoretical concept of electronic circuit with practical feasibility.
- To acquire experience on electronic circuits for real life applications.

Semester-II

Paper: ELC -201 :Electromagnetism and Antenna

Full Marks: 50 Credit: 4

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. *5h*
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. *5h*
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. *5h*
5. Radiation: Potential functions and Electromagnetic field. Alternating current element, Hertzian dipole, Radiation from quarter wave monopole or half wave dipole. *5h*
6. Antenna fundamentals: Fundamental parameters of antenna- Radiation Pattern, Radiation Power density, Radiation Intensity, Beam-width, Directivity, Antenna efficiency, Gain, Beam efficiency, Polarization, Input impedance, Antenna radiation efficiency, Antenna effective wavelength and equivalent areas, Max. Directivity. *5h*
7. Introduction to antennas: Resonant and non resonant antennas, Wire antenna, Loop antenna, Horn antenna, parabolic reflector, Lens antenna, Helical antenna, Log periodic antennas, Travelling Wave antenna, Rhombic antenna. *5h*
8. 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. *5h*

Course Outcome (CO)

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.

Paper-ELC 202: Signals and Systems

Full Marks: 50, Credit: 4

1. Introduction: Signal definition, different types of signals: analog & discrete. Time domain and frequency domain representation, periodic and aperiodic signals, energy and power signal, deterministic and non-deterministic signal, signals and vector analogy, othogonality of signal functions, some useful signal operations. *5h*
2. Sequences: classification based on length, symmetry, periodicity, energy, power, generation of sequences, special sequences, arithmetic operations on sequences. *4h*

3. Basis function and concept of generalized Fourier series: Fourier transform of some useful functions, convolution and correlation in time domain and frequency domain. Perseval's theorem, energy spectral density, essential bandwidth of a signal, energy of the modulated signal, time autocorrelation function and the energy spectral density, power spectral density, time autocorrelation function of power signals, Input and output power spectral densities, PSD of modulated signals.

6h

4. LTI Systems: Convolution, graphical & analytical techniques, overlap & add method, sliding tape method, numerical problems on LTI systems, properties of convolution and interconnection of LTI systems, de-convolution, stability of systems, casual systems, recursive and non-recursive systems, difference equation, implementation of systems, Direct Form I and II structures, concepts of IIR & FIR systems, moving average system. *5h*
5. Discrete Fourier Transform: DFT and IDFT relationship, Twiddle factors, linear transformations, basic properties, , multiplication of DFTs, circular convolution, linear filtering using DFT, filtering of long data sequences, overlap and save method, overlap and method.

5h

6. Fast Fourier Transform: Efficient computation of DFT, FFT algorithms, Radix-2 algorithm, decimation in-time and decimation-in-frequency algorithms, signal flow graph, butterflies, computation in one place, bit reversal, DFT computations using DIT & DIF algorithms. *5h*

7. Signal detection: Model of digital communication system, geometric interpretation of signals, Schwarz's inequality, concepts of orthogonality and orthonormality, Gram- Schmidt orthogonalization process, roles of multipliers and correlators, bank of correlators in noisy environment, channel characterization, likelihood functions, memory less channel, signal detection in presence of noise, maximum-likelihood detector, observation space, decision regions, conditional probability of symbol error, error function, complementary error function, correlation receiver, matched filter receiver, maximization of signal to noise ratio, properties of matched filter.

10h

Course Outcome (CO):

At the end of this course students will develop their:

- Basic concepts of different signals and systems in detail.
- Understanding to analyze various kinds of systems through proper use of Fourier transforms.
- Knowledge of signal detection in detail.

Paper - ELC-203: Digital System Design

Full Marks: 50, Credit: 4

1. Introduction**:** Extensive review on logic gates (using transistor, diode etc) & logic families detail circuit analysis of RTL, HTL, TTL, NMOS, & CMOS Families. *4h*

2.Logic circuits & Minimization Techniques: logic variables, logic constants, Logic functions- NOT, AND, OR, NAND, NOR, Ex-OR, Boolean algebra and Karnaugh map simplification (SOP and POS).

7h

3. Combinational Circuit: Analysis and synthesis of combinational circuits, multiplexer, de-multiplexer, encoder, decoder, code-converter, adder, subtractor, comparator, parity generator/checker, Programmable Logic Devices (PLD), CPLD *10h*

4.Sequential Circuit **:** S-R, D, T, J-K flip-flop, Master –Slave flip-flop, Flip-Flop Conversion, Synchronous & asynchronous counter register, shift register, preset & clear functions, Ring and Johnson Counter. *10h*

5. Converters: Specification of converter, R-2R ladder type D/A converter, Successive approximation converter, The Dual slope converter**.** *4h*

6. Finite state machine**:** Analysis and Design of fundamental mode state machines: State variables, State table and State diagram**.** *5h*

Course Outcome (CO)

- Acquire fundamental idea of logic gates using diodes and analysis of different logic families like TTL, ECL MOS etc.
- Obtain knowledge about different combinational logic circuits and sequential logic circuits.
- Acquire knowledge to understand ADC/DAC.
- Acquire knowledge about finite state machine

C-ELC 204 (CBCS) Paper I: E-Waste and Renewable Energy

Full Marks: 50, Credit: 4
C-ELC 204A: E-Waste
Full Marks: 25, Credit: 2

1. Introduction: Definition of e-waste, Composition of e-waste, Global scenario of e-waste, E-waste generation in India, Hazardous substances in e-waste, Impacts of e-waste on environment and human health. Component of e-waste management, Emerging recycling and recovery technologies, Guidelines for environmentally sound management of e-waste, Occupational and environmental health perspectives of recycling e-waste in India. *10h*
2. E-waste hazardous trade: Essential factors in global e-waste trade economy, Import of hazardous e-waste in India, E-waste economy on the organized and unorganized sector. *3h*
3. E-waste legislation: The international legislation: The Basel convention, Waste Electrical and Electronics Equipment (WEEE) directive in the European Union, Restriction ofhazardous substance (RoHS) directive. Regulatory bodies for e-waste in India, E-waste (Management and Handling) rules 2011, E-waste management rules 2022- salient features, Roles and responsibilities of different stakeholders- producer, manufacture, consumer; Extended producer responsibility

(EPR), Proposed reduction in the use of RoHS.

7h

Course Outcome (CO):

When a student completes this course, s/he should be able to:

- Understand the meaning of e-waste and key terms associated with e-waste.
- Understand the impacts of e-waste on environment, health and society.
- Have a basic idea on e-waste hazardous trade.
- Understand the key elements of e-waste management and various national and international acts and laws applicable for e-waste management.

C-ELC 204B: Renewable Energy

Full Marks: 25, Credit: 2

1. Introduction: Forms of energy, Conservation of energy, Energy flow diagram to the earth, Origin of fossil fuels, Conventional energy sources, Role of energy in social transformation. *3h*
2. Energy Scenario: Energy consumption in various sectors, Exponential increase in energy consumption, Energy demand and energy trilemma index, Classification of energy sources, Conventional and nonconventional energy, Renewable and non-renewable energy, Green energy, Clean energy, Green footprint, Carbon footprint, Ecological footprint. Energy resources in India, Urban and rural energy consumption, Nuclear energy- promise and future, Need for use of new and renewable energy sources, National Green Tribunal (NGT) act. *8h*
3. Environment Impacts: Environmental degradation due to energy production and utilization, Global warming, Environmental effects of thermal power station, Nuclear power generation, hydroelectric power. *3h*
4. Solar Photovoltaic and Solar Thermal Conversion: Solar radiation spectrum, Solar constant, Classification of solar cells: First generation, Second generation, Third generation; PV solar cell, module, Panel and array, Solar thermal system types, Applications of solar PV and solar thermal systems. *6h*

Course Outcome (CO):

At the end of the course, students will acquire knowledge on:

- Different sources of energy and role of energy in social transformations.
- Global and national energy scenarios.
- Environmental impacts due to energy production and utilization.
- Solar photovoltaic and solar thermal conversion processes.

Paper: ELC-295: Digital Circuit Laboratory (Practical)
Full Marks: 50, Credit: 4

1. Design and Implementation of simple arithmetic circuits-Adder, Subtractor.
2. Design and Implementation of two bit parity generator.
3. Design and Implementation of four bit comparator circuit.
4. Design and Implementation of BCD to Binary & Vice Versa.
5. Design and Implementation BCD to Decimal conversion to drive 7-segment display using MUX.
6. Design and Implementation of RS, JK and MS flip flop.
7. Realization of MOD counter.
8. Realization of Ring counters.
9. Realization of Universal register using J-K & logic gate.
10. Realization of logic Gates using CMOS.
11. Design and Implementation Astable Multivibrator using 555 timer.
12. Design and Implementation of D/A using R-2R ladder.

Course Outcome (CO):

At the end of this course students will.

- Design different combinational and sequential circuits like adder, subtractor, multiplexer, flip-flops, registrars, 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.

PAPER : ELC 296: Semiconductor Device Lab (Practical)

Full Marks: 50, Credit: 4

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 (CO):

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.

SEMESTER –III

PAPER -ELC 301: Electronic Communication
Full Marks: 50 Credit: 4

1. Amplitude modulation: Modulation principle and definitions, sideband and carrier power, generation of AM signal, demodulation of AM signal. Different type of modulator circuits, square law modulator, balanced modulator, etc. Demodulator basic principle of coherent detections, square law detectors, envelope detectors. single sideband (SSB), generation of SSB signals, selective filtering method, phase shift method, demodulation of SSB-SC signals, envelope detection of SSB signals with a carrier (SSB+C), vestigial sideband (VSB), envelope detection of VSB+C signals. Quadrature amplitude modulation (QAM). *10h*

2. Distortion analysis. Random signals, noise, noise temperature and noise figure, autocorrelation and power spectral density, properties of white noise, filtering of random signals through LTI systems. *5h*

3.Frequency and phase modulation: Principles and definitions, relationship between frequency and phase modulations. phase and frequency deviations, spectrum of FM signal, bandwidth considerations. Effect of modulation index on bandwidth, narrow band and wideband FM and PM principles, circuit for realization of FM and PM. different type of demodulator, discriminator, use of PLL etc. Radio transmitter: Basic block diagram of radio transmitter (AM and FM), Analysis of a practical circuit diagram used for medium power transmitter. Super heterodyne receiver. *10h*

4.Digital communications: Sampling theorem and applications, PCM, DPCM, Delta modulation, digital modulation schemes (ASK, PSK, FSK, QAM),bandwidth, Time and Frequency-Division Multiplexing, Multiple Access techniques, inter-symbol interference, MAP, ML detection, matched filter receiver, SNR and BER. Basic concepts of information theory, Fundamentals of error correction, Hamming codes, CRC. Data Communications – Modems, Codes, Basic concepts of digital signal processing, digital filters – IIR, FIR. *10h*

5.Principles of Mobile Communication: Optical communication, Optical fibers – attenuation and dispersion characteristics, Bandwidth, Wavelength division multiplexing. Fundamentals of Internet of Things (IoT) for communication. 10*h*

Course Outcome (CO):
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.

PAPER - ELC 302 : VLSI Design and Technology
Full Marks: 50 Credit: 4

1. Design Process: Overview of VLSI design methodologies, VLSI design flow, Design hierarchy, Concept of regularities, Modularity and locality, VLSI design styles, Design quality, Computer aided design technology. *4h*
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, Introduction to scaling- constant field scaling, constant voltage scaling; MOSFET scaling and small-geometry effects, MOSFET capacitance. *6h*
3. VLSI Technology: Fabrication facilities: pure water system, clean room; Crystal growth and wafer preparation, Epitaxial growth, VPE, LPE and MBE mechanisms, Oxidation: Growth mechanism and kinetics, Thin oxide, Oxide properties, Redistribution of dopants at interface.
   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 methods. 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: NMOS, CMOS, Bipolar IC, Bi-CMOS, Silicon on insulator (SOI), Fin-FET technology. Packaging: Package types, Package design considerations. *15h.*
4. Basic Integrated Circuit Building Blocks: Introduction, Switches, Active resistor, Current sources and sinks, Current mirror amplifiers, Voltage and current references. *3h*
5. Analog Design: Inverting amplifier: General concept of inverting amplifier, MOS inverting amplifier; Current-driven CMOS cascode amplifier, Voltage-driven CMOS cascode amplifier:; CMO differential amplifier, Operational amplifier: Characterization of Op-Amps, CMOS two-stage OP-AMP. *6h*
6. Digital Design:Logic level standards, Single-channel MOS inverter, Inverter pair characteristics, Logic fan-out characteristics, Digital logic design, CMOS design methodology, Basic CMOS inverter, CMOS inverter logic levels, CMOS logic gates: CMOS inverter (NOT) gate, CMOS NOR and CMOS NAND logic gates. Classification of digital logic circuits: combinational and sequential logic circuits, Pseudo- NMOS logic, CMOS transmission gate, Dynamic CMOS logic circuit,

Domino CMOS logic, NORA CMOS logic, Zipper CMOS logic, Pass transistor logic, Complementary pass transistor logic. *6h*

Course Outcome (CO):

With the basis, students will be able to have clear concepts on:

- VLSI design flow and design styles.
- Physics of MOS transistor.
- Fabrication process of IC technology.
- VLSI design techniques for analog and digital circuits.

Paper-ELC 303: Control System and Instrumentation
Full Marks 50. Credit: 04

1. Introduction: Concepts of Control Systems- Open Loop and closed loop control systems and their differences- Types of feedback control system. *1h*
2. Transfer Function Representation: Transfer Function of linear systems, Block diagram Reduction method, Signal flow graph, Mason's gain formula. *6h*
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. *6h*
4. Stability Analysis: The concept of stability – Routh's stability criterion, Root Locus Technique: The root locus concept. *5h*
5. Frequency Response Analysis: Bode diagram, Phase margin and Gain margin, Stability Analysis from Bode Plots, Polar Plots, Nyquist Plot stability analysis. *6h*
6. Transducers: Resistance, inductance, capacitance, piezoelectric, thermoelectric and Photoelectric transducer, Hall effect measurement, Measurement of displacement, velocity, acceleration, force, torque, strain, temperature, pressure, flow, humidity, thickness, pH and position. *6h*
7. Measuring equipments: Measurements of R, L and C. Digital Storage Oscilloscopes, Logic state analyzer, Signal generators, Distortion analyzer, Spectrum analyzer, Instrumentation amplifiers, and Radio telemetry. *6h*
8. Analytical Instrument: Spectrophotometers, Electron microscope. *2h*
9. Biomedical instruments : ECG and blood pressure measurements. *2h*

Course Outcome (CO):

- 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.
- Acquire basic concept and definitions of measurements.

- Acquire knowledge on working of various measuring equipment like digital storage oscilloscopes, logic state analyzer, signal generators, distortion analyzer, spectrum analyzer, instrumentation amplifiers, and radio telemetry.
- Obtain knowledge about analytical instruments and biomedical instruments like spectrophotometers, Electron Microscope ECG and blood pressure measurements.

Paper- ELC-304: Introduction to Electronics

Full Marks: 50, Credit: 4

1. Semiconductor Diodes and Applications: p-n junction diode, Characteristics and Parameters, Diode approximations, DC load line analysis, Half-wave rectifier, Two-diode Full-wave rectifier, Bridge rectifier, Capacitor filter circuit (only qualitative approch), Zener diode voltage regulators: Regulator circuit with no load, Loaded Regulator. Numerical examples as applicable. *6h*
2. Bipolar Junction Transistors: BJT operation, BJT Voltages and Currents, BJT amplification, Common Base, Common Emitter and Common Collector Characteristics, Numerical examples as applicable. *5h*
3. BJT Biasing: DC Load line and Bias Point, Base Bias, Voltage divider Bias, Numerical examples as applicable. *4h*
4. Introduction to Operational Amplifiers: Ideal OPAMP, Inverting and Non Inverting OPAMP circuits, OPAMP applications: voltage follower, addition, subtraction, differentiation; integration, Numerical examples. *5h*
5. Digital Electronics: Introduction, Switching and Logic Levels, Digital Waveform. Number Systems: Decimal Number System, Binary Number System, Converting Decimal to Binary, Hexadecimal Number System: Converting Binary to Hexadecimal, Hexadecimal to Binary, Converting Hexadecimal to Decimal, Converting Decimal to Hexadecimal, Octal Numbers: Binary to Octal Conversion. Complement of Binary Numbers. Boolean Algebra Theorems, De Morgan's theorem. Digital Circuits: Logic gates, NOT Gate, AND Gate, OR Gate, XOR Gate, NAND Gate, NOR Gate, X-NOR Gate. Algebraic Simplification, NAND and NOR Implementation; Half adder, Full adder. *10h*
6. Introduction to Flip-Flops: NAND Gate Latch/ NOR Gate Latch, RS Flip-Flop, Gated Flip-Flops: Clocked RS Flip-Flop. *5h*
7. Communication Systems: Introduction, Elements of Communication Systems, Modulation: Amplitude Modulation, Spectrum Power, AM Detection (Demodulation), Frequency and Phase Modulation. Amplitude and Frequency Modulation: A comparison. *5h*

Course Outcome (CO):

After completing this course, the other departmental students will

- Acquire fundamental knowledge in Analog electronic systems
- Acquire fundamental knowledge in Digital electronic systems
- Acquire fundamental knowledge in electronic communication systems

Paper- ELC-395: Electronic and Optical Communication Lab (Practical)

Full Marks: 50, Credit: 4

1. To study generation and characteristic studies of Amplitude Modulation (AM) and Demodulation Techniques.
2. To study generation and characteristic studies of Amplitude DSBSC and Demodulation Techniques.
3. To study generation and characteristic studies of SSBSC and Demodulation Techniques.
4. To study generation and characteristic studies of Frequency Modulation (FM) and Demodulation Techniques.
5. To study generation and characteristic study of Pulse Amplitude Modulation (PAM).
6. To study generation and characteristic study of Pulse Width Modulation (PWM).
7. To study numerical aperture of optical fibre.
8. To study frequency response characteristics of LDR.
9. To study optical conversion of digital to analog signal.
10. To study measurement of dimension of circular aperture by laser.

Course Outcome (CO)

At the end of this course students will be able to:

- Generate different modulated and demodulated signals and characterize them for advancement of the communication systems.
- Measure numerical aperture of different optical fibres, dimension of circular aperture.
- Determine pulse broadening in an optical fibre.
- Perform different experiments using optoelectronic devices (LDR, LASER) for better results in communication.

Paper-ELC-396: VLSI LAB (Practical)

Full Marks: 50, Credits: 4

SPICE based experiments

1. To study schematic diagram of MOS inverter with different loads.
2. To study schematic diagram of two input NAND gate.
3. To study schematic diagram of two input NOR gate.
4. To study schematic diagram of different logic circuits.

Layout Based experiments

1. Draw layout of CMOS inverter
2. Draw layout of two input NAND gate.
3. Draw layout of two input NOR gate.
4. Draw layout of any logic circuit.

VHDL/Verilog based experiments

1. Implement and simulate half added, full adder, hulf subtractor and full subtractor circuit.
2. Implement and simulate multiplexer.
3. Implement and simulate decoder circuit.
4. Implement and simulate magnitude comparator circuit.
5. Implement and simulate flip-flop.
6. Implement and simulate counter circuit.

Course Outcome (CO):

At the end of this course student will

- Acquire fundamental knowledge of VLSI circuit design and implementation using circuit simulators and layout editors.
- Familiar with SPICE simulation model parameter.
- Acquire knowledge to obtain characteristics of MOS inverters with different loads using SPICE simulator and transient and transfer responses of CMOS inverter.
- Learn to implement any digital logic circuits using schematic editors.
- Able to design the layout of CMOS NAND/NOR gate using layout design tool.
- Learn to implement logic gates using FPGA.
- Able to write VHDL/VARILOG programming.

SEMESTER –IV

PAPER - ELC 401: Microprocessor and Microcontrollers
Full Marks: 50, Credit: 4

1. Introduction to microprocessor 8085:Architecture of 8085, Address/data bus de-multiplexing, Register organization, Addressing modes, Instruction set, Assembly language program development using instructions for viz. Code conversion, Multiple addition and subtraction, Multiplication, Division etc.; Interrupts, Memory interfacing, Concept of memory mapping.

   4h
2. The processor 8086:8086 architecture, Functional block diagram, Register organization, Memory segmentation, Programming modes, Memory access, Physical memory organization, Signal description of different pins, Timing diagram, Interrupts. Instruction set and assembly language programming, Instruction addressing modes, Assembler directives, Simple program development using instructions.

   13h
3. Interfacing: Memory and I/O interfacing, Memory mapped I/O and peripheral I/O, Basic concepts on the devices 8255, 8259, 8155, 8279, 8251 and their interfacing with microprocessor. *10h.*
4. Serial I/O and data communication: Serial communication protocols, Synchronous and asynchronous communication, RS 232 serial interface standard, IEEE 488 standard, Current loop interface, Error detection and correction. *3h.*
5. Microcontroller 8051:Architecture of 8051 microcontroller, Memory organization, Addressing modes and instruction set, Useful assembly language programs using instructions of 8051, Interfacing of ADC/DAC, Display, Keyboard and Stepper motor.

   10h.

Course Outcome (CO):

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.

Paper-ELC-402: Digital Signal Processing

Full Marks: 50, Credit: 4

1.Discrete Time signal: Discrete time signal, basic idea of sampling and reconstruction of signals, sampling theorem, sequences-periodic signal, energy signals, power signal, unit step, unit ramp, real and complex exponentials, arithmetic sequences on sequences. *3h*

2. LTI system: Definition, representation, impulse response, derivation for the output sequence, concept of convolution, graphical, analytical and overlap-add methods to compute convolution supported with examples and exercises, properties of convolution, interconnections of LTI systems with physical interpretations, stability and causality conditions, recursive and non-recursive systems. *6h*

3. Z-Transforn: Definition, mapping between s-plane and z-plane, unit circle, convergence and ROC, properties of Z-transform, Z-transform on sequences with examples and exercises, characteristic families of signals along with ROCs, convolution, correlation and multiplication using Z-transform, initial value theorem, Perseval's relation, inverse Z-transform by contour integration, power series & partial-fraction expansions with examples and exercises *6h*

4. Discrete Fourier Transform: Concept and relations for DFT/IDFT, Twiddle factors and their properties, computational burden on direct DFT, DFT/IDFT as linear transformations, DFT/IDFT matrices, computation of DFT/IDFT by matrix method, multiplication of DFTs, circular convolution, computation of circular convolution by graphical, DFT/IDFT and matrix methods, linear filtering using DFT, aliasing error, filtering of long data sequences – Overlap-Save and Overlap- Add methods with examples and exercises. *6h*

5. Fast Fourier Transform: Radix-2 algorithm, decimation-in-time, decimation-in-frequency algorithms, signal flow graphs, Butterflies, computations in one place, bit reversal, examples for DIT & DIF FFT Butterfly computations and exercises. *5h*

6. Filter Design: Basic concepts of IIR and FIR filters, difference equations, design of Butterworth IIR analog filter using impulse invariant and bilinear transforms, design of linear phase FIR filters, no. of taps, rectangular, Hamming and Blackman windows. *5h*

7. Digital Signal Processor: Elementary idea about the architecture and important instruction sets of TMS320C 5416/6713 processor, writing of small programs in Assembly Language. *3h*

8. FPGA: Architecture, different sub-systems, design flow for DSP system design, mapping of DSP algorithms onto FPGA *3h*

9. An introduction to the theory of two-dimensional signal processing, applications of Digital Signal Processing to speech and RADAR. *3h*

Course Outcome (CO):

After completion of this course the student

- Knows basic discrete-time signal and system types, convolution sum, impulse and frequency response concepts for linear, time-invariant (LTI) systems, difference equation realization of LTI systems and discrete-time Fourier transform and basic properties of these.

- Understands periodic sampling of analog signals and the relation between Fourier transforms of the sampled analog signal and the resulting discrete-time signal.
- Understands the basic properties of system functions and frequency responses of LTI
- Learns basic digital filter design methods: (i) Learns analog Butterworth and Chebyshev filters transformed to yield digital IIR filters, (ii) impulse-invariance and bilinear transformation methods for IIR filter design and (iii) FIR filter design methods based on windowing.

Elective –I: Paper- ELC 403A : RF and Microwave Systems

Full Marks: 50, Credit: 4

1. Introduction: Basic Microwave concepts, Microwave and millimetre wave frequencies. *5h*
2. Microwave Network: General approach to microwave circuit analysis, S parameters, Relation between S and Z parameters. *5h*
3. Cavity Resonators: Rectangular, Circular and Semicircular Cavity resonators, Q-factor. *3h*
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. *7h*
5. Microwave Tube: Microwave linear beam tubes, Klystrons, Reflex klystron, TWT, Microwave crossed field tubes: Magnetron. *4h*
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. *6h*
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. *6h*
8. Satellite Communication: Concept of satellite communication, Link Budget. *4h*

Course Outcome (CO):

After completion of this course, the students will able to develop

- Basic ideas on cavity resonators and microwave passive circuits.
- Basic ideas on microwave sources (Vacuum Tube) and microwave solid state Sources.
- Basic ideas on radar communications.

Elective –I: Paper -ELC 403B : Renewable Energy

Full Marks: 50, Credit: 4

1. Introduction: Work, Power and Energy: Work done by constant and variable forces, Work-energy theorem, Significance of work-energy theorem, Power, Conservative and non-conservative forces. Forms of energy, Conservation of energy, Energy flow diagram to the

earth, Origin of fossil fuels, Conventional energy sources, Role of energy in social transformation. *4h.*

2. Global Energy Scene: Energy consumption in various sectors, Exponential increase in energy consumption, Energy resources: coal, oil, natural gas, nuclear and hydroelectric power, Impact of rise in energy usage on world economy, Energy demand and energy trilemma index, Classification of energy sources, Conventional and nonconventional energy, Renewable and non-renewable energy, Green energy, Clean energy, Green footprint, Carbon footprint, Ecological footprint. *7h*
3. Indian Energy Scenario: Energy resources in India, Urban and rural energy consumption, Energy consumption pattern and its variation with time, Nuclear energy- promise and future, Need for use of new and renewable energy sources, National Green Tribunal (NGT) act. *5h*
4. Environment Impacts: Environmental degradation due to energy production and utilization, Air and water pollution, Ozone layer depletion, Global warming, Environmental effects of thermal power station, Nuclear power generation, hydroelectric power, Geothermal power, Harvesting of ocean energy, wind energy, solar energy and bio-energy; Biological damage due to environmental degradation. *7h*
5. Solar Photovoltaic and Solar Thermal Conversion: Solar radiation spectrum, Solar constant, Classification of solar cells: First generation, Second generation, Third generation; PV solar cell, module, Panel and array, Solar thermal system types, Applications of solar PV and solar thermal systems. *6h*
6. Wind Energy: Introduction, Principle of wind energy conversion, Advantages and disadvantages of wind mills, Applications of wind energy. *3h*
7. Geothermal Energy: Introduction, Estimates of geothermal power, Nature of geothermal fields, Geothermal resources. *2h*
8. Ocean Energy: Introduction, Principle of ocean thermal energy conversion (OTEC), Energy from waves, Wave energy technologies. *3h*
9. Bio-Energy: Energy from biomass, Sources of biomass, Properties and characteristics of biomass, Conversion of biomass into fuels. *3h*

Course Outcome (CO):

On learning this course, students will acquire knowledge on:

- Various energy sources and importance of energy for sustainable growth.
- Global and national energy perspective.
- Environment impacts due to energy production and utilization.

- Solar photovoltaic and solar thermal techniques.
- Basic of wind energy, geothermal energy, ocean energy and bioenergy.

Elective –I: Paper - ELC 403C: Power and Industrial Electronics

Full Marks: 50, Credit: 4

1. Power devices, characteristics of SCR, DIAC, TRIAC, UJT, power transistors, Power MESFETs and MOSFETs Protection of thyristors against over voltage and over current. SCR triggering - dv/dt and di/dt, triggering with single pulse and train of pulses *7h*
2. A.C. and D.C. motors - construction and speed control. *4h*
3. Switched Mode Power Supply (SMPS). Uninterrupted Power Supply (UPS). *4h*
4. Transformer: Principle and equivalent circuit, core loss and copper loss, three phase connection, Winding arrangement of a DC and AC rotating machine, Concept of rotating MMF. *5h*
5. Choppers: AC and DC choppers using MOSFETs, Step Up, Step Down, Single quadrant, double quadrant, four quadrants, Morgan Choppers and Jones Choppers. *5h*
6. Inverter: Voltage driven and Current Driven Inverter, transistor/IGBT inverter, SCR inverter. *5h*
7. Digital Control, PLC, Ladder diagrams, Supervisory Control and Data Acquisition, typical SCADA System Architecture, Communication Requirements, Desirable properties of SCADA system, Features, advantages, disadvantages and applications of SCADA. SCADA Architecture (First Generation-Monolithic, Second Generation-Distributed, Third generation Networked Architecture). 10*h*

Course Outcome (CO):

After completion of this course students will develop

- Knowledge on functioning mechanism and applications of various power device DIAC, TRIAC, SCR , UJT and Power Transistors.
- Knowledge on functioning mechanism and applications of AC , DC Motors, Transformers and Inverters.
- Basic ideas on digitally controlled power devices.

Elective –II: Paper - ELC 404A : Optical Communication and Photonic Devices

Full Marks: 50, Credit: 4

1. Perturbation theory: Time independent and time dependent, Fermi's Golden rule for transitions. *3h*

2. Optical fiber: Basic principles of light propagation, types of optical fiber, Application of optical fiber in communication and its Advantages, Optical fibers - modal propagation-Ray Model, Wave Model. *5h*
3. Attenuation in optical fiber, Signal distortion on optical fibers Material Dispersion, Intermodal and Intramodal, Loss Mechanism in Optical Fibers-Absorption and Scattering, Fresnel Reflection, Micro bending & Macro bending radiation, Connector types and Splices, Misalignment and Mismatch losses, The Optical Directional Copular. *6h*
4. Optical sources: LEDs, Direct band gap semiconductors, Spontaneous emission, structures, Internal quantum efficiency, Linearity, Radiation pattern and spectra, Modulation characteristics, Transient response; Lasers: Stimulated emission and lasing, Laser structures, Radiation pattern and spectra, Narrow-line width lasers, Modulation characteristics: Threshold current and its temperature sensitivity, Turn-on delay, Linearity; Gas Laser, Semiconductor laser. *7h*
5. Pulse coding principle, Multiplexing and de-multiplexing of signal: Time Division Multiplexing and De-multiplexing, Wavelength Division Multiplexing and De-multiplexing. *5h*
6. Photo receivers, Photoconductors, Semiconductor Photodiodes, Photo Transistors, noise. Optical link design, power penalty. SONET/SDH, DWDM, optical switches, Fiber Amplifiers, EDFA, DRA, WDM networks and components and Optical CDAMA. *5h*
7. Parallel Optical Computation and data processing: Digital optics, Optical logic gates, Half-adder, Full-adder *3h*
8. Communication with laser as source (Channel based and channel less), LlDAR. *3h*
9. Non-linear Optics: Non-linearity of medium, second and higher harmonic generation, phase matching condition, frequency addition and frequency subtraction. *3h*

Course Outcome (CO):

After completion of this course students will develop knowledge on

- Perturbation theory: Time independent and time dependent, Fermi's Golden rule for transitions.
- Optical fibers: basic ideas, optical sources, detectors and transmitting mechanisms.
- Parallel optical computation and data processing.
- LASER and non-linear optics.

Elective –II: Paper - ELC 404B : Nanostructures and Characterization

Full Marks: 50, Credit: 4

1. Fundamentals: History of nanotechnology, Feynman's vision on nano-science and technology, Bulk vs. nanomaterial, Clusters and magic numbers, Nanoscale architecture. *3h*
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 nanotubes, micro and mesoporous materials, core-shell structures, organic-inorganic hybrids. *8h*
3. Properties on size and shape: Size and shape dependent properties, Band structure of materials at Nanoscale, Density pf states of materials at Nanoscale, Mechanical properties, Thermal properties, Optical properties, Magnetic properties, Electrical properties. *7h*
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). *10h*
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. *12h*

Course Outcome (CO):

At the end of this course, students will acquire knowledge on:

- Basic of nano-materials and different dimensions of nanostructures.
- Mechanical, thermal, optical, magnetic and electrical properties of nano-materials.
- Different processes of synthesis of nano-materials.
- Characterization techniques of nano-materials.
-

Elective –II : PAPER : ELC 404C : Computer Network and Security

10. Full Marks: 50, Credit: 4

I. Data communication fundamentals: Serial and parallel communications, protocols, error checking and correction. *4h*

2. Network configurations: Bus, Star, Ring etc. *4h*

3. Communication Hardware and Software: Ethernet. Token Ring, FOOI, CODI etc. Concept of packet, Cell etc. TCP/IP, X 25, ISO-7 layer protocol, ATM. *5h*

4. Network Hardware: HUB, Bridge, Switch, Router etc. *2h*

5. Basic switching: PCM Fundamentals, PCM hierarchies (PDH), Digital switching concepts, Basic architecture of a digital switch, signaling (including R2, CCS7). *5h*

6. Basic Transmission: PDH, OFC (2, 8, 34, 140. 565 Mbps), Digital Microwave systems (6, J 1,7,13 GHz).
7. PSTN Topology and Planning: Hierarchies of a typical telecom network, subscriber access network, Network planning. *7h*

8. Services: Value added and intelligent network, ISDN and leased line. *3h*

9. Mobile Communication Networks: Wireless links, FDMA, COMA, Base station and controller, Mobile Switching Centre, Call authentication and billing - HLR, VLR, Queries etc. based mobile telephony. *7h*

10, Introduction to network security. Fundamental concepts. *3h*

Course Outcome (CO):

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.

PAPER - ELC 495: Microprocessor and Microcontrollers Lab (Practical)

Full Marks: 50, Credit: 4

1. Assembly language programs for arithmetic operations (Addition, Subtraction, Multiplication, Division, Code-conversion etc.) with 8085/8086 processor.
2. Interfacing of discrete LEDs, 7-segment displays, Multiplexed 7 –segment displays to 8255 PPI IC and with 8085/8086 processor.
3. Interfacing of ADC and DAC with 8085/8086 processor.
4. Interfacing of stepper motor with 8051 microcontroller.
5. Experiments with Arduino.

Course Outcome (CO):

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.

PAPER -ELC 496 : Project/Internship

Full Marks: 50 Credit: 4

Course Outcome (CO):

Project work/Industrial training is an important part in the syllabus to grow a student strong enough to sustain in the real world. At the end of the programme students will be:

- Fit for higher studies, research work and industrial work.
- Able to develop an entrepreneurship program.
- Courageous to participate in the nation building programs like Start upbusiness, Make in India.

Recommended Books

Semester -I

- Mathematical methods for Physicists, G. Arfken.
- Introduction to Mathematical Physics, Harper.
- Mathematical Method (2nd et), Potter.
- Advanced Engineering Mathematics, M.D: Greenberg.
- Complex Variables and Applications, R V Churchill.
- Theory and problems on Laplace Transforms, Spiegel.
- Numerical Analysis, Scarbarroh.
- Electronic Properties of Materials, R. E. Hummel, Springer, New York Publication.
- Electrical Engineering Materials, A. J. Decker, Prentice Hall of India Private Limited, New Delhi- 110 001.
- Principles of Electronic Materials and Devices, S. D. Kasap, McGraw-Hill Education (India) Pvt. Ltd.
- Materials Science & Engineering, W. D. Callister,Jr, Willy India (P) Ltd.
- The Physics of Low-dimensional Semiconductors- an Introduction, J.H. Davies, Cambridge University Press.
- 2D Materials for Nanoelectronics, M. Hussa, A. Dimoulas and A. Molle, CRC Press.
- Microeletronic Circuits and Devices, Horenstein.
- Microelectronic Circuits, AS. Sedra and KC. Smith.
- Microelectronics, Millman and Taub.
- Circuit theory, Chattopadhay and Rakshit
- Network analysis, Van Valkenberg.
- Electronic circuit analysis and design, Hyat and Neudeck.
- Basic Circuit Theory, L.P Huelsman
- Electronic Devices and Circuit Theory, Boylested and Nashelaky, Pearson
- Electronic Devices and Circuits, Mottershed. Prentice-Hall of India Pvt.Ltd
- Integrated Electronics, Millman and Halkias. Tata McGraw-Hill Publishing Co
- Electronics Principles, Malvino, McGraw Hill Education India
- Electronics Fundamental and Application, Chattopadhyay and Rakshit, New Age Internationals
- Application and Design of Analog Integrated Circuits, Jacob. Regents/Prentice Hall,
- Operational Amplifiers and Linear Integrated Circuits, Coughing and Discolt 34. OP-AMPS Linear Integrated Circuits, Gaykwad, Pearson

- Linear Integrated circuits by D. Roy Choudhury and salil B. Jain, New Age Publisher
- Electronics Circuits by Adel S Sedra & Kenneth Carless Smith, Oxford University Press
- http://docs.python.org/3/tutorial/index.html
- http://interactivepython.org/courselib/static/pythonds
- T. Budd, Exploring Python, TMH, 1st Ed, 2011
- How to think like a computer scientist: learning with Python / Allen Downey, Jeffrey Elkner, Chris Meyers. 1st Edition – Freely available online.2012.

Semester –II

- Introduction to Electodynamics, Griffith.
- Electromagnetic Waves & Radiating Systems, Jordan and Baihnan.
- Microwave propagation and technique, D.C. Sarkar
- Microwave Device and Circuits, Liao.
- Elements of Engineering Electrodynamics, M.M. Rao.
- Networks, Lines and Fields, Ryder
- Digital Electronics, Gothmann., Prentice-Hall of India Pvt.Ltd
- Digital Principles and Applications, Malvino and Leach., McGraw-Hill Education - Europe
- Digital Electronics, Malvino, McGraw Hill Education India
- Digital Computer Electronics, Malvino and Brown. McGraw Hill Education India
- Digital Systems: Principales and practices, Tocci, Pearson
- Digital Circuits and Design by S. Salivahanan, Vikas Publishing House Pvt Ltd
- Fundamental of digital circuit by Anand Kumar, PHI Learning
- Digital Integrated circuits by Rabaey, Prentice-Hall, Inc.
- VHDL Primer by J. Bhasker, Prentice-Hall of India Pvt.Ltd
- Verilog HDL by Samir Palnitkar, Prentice-Hall, Inc.
- "E-waste: Implications, Regulations and Management in India and Current Global BestPractices", TERI Press, New Delhi.
- "Electronic Waste Management- Design, Analysis and Application", R. E. Hester and R. M. Harrison, Royal Society Chemistry (RSC) Publication.
- "Electronic Waste: Toxicology and Public Health Issues", B. Fowler, Elsevier.
- Principle of Communication Systems, D. Schilling and H. Taub.
- Signal Processing and Linear Systems: B.P.Lathi.
- Analog and Digital Communications, Roden.
- Electronic communication, Roddy and Coolen.
- Digital Signal Processing: Principles, algorithms and applications,J.G. Proakias & D.G.Manolakis, PHI
- Digital Signal processing: Hands on approach, C. Schuler and M. Chugani, TMH

- Discrete Time Signal Processing, A.V. Oppenheim and R.W. Schaffer, PHI

Semester –III

- Communication Systems, Kennedy.
- Communication Systems, B. Carlson.
- Principle of Communication Systems, D. Schilling and H. Taub.
- Signal Processing and Linear Systems: B.P.Lathi.
- Communication Systems: B.P.Lathi.
- Analog and Digital Communications, Roden.
- Electronic communication, Roddy and Coolen.
- "Fundamentals of Semiconductor Fabrication", G. S. May and S. M. Sze, John Wiley & Sons (Asia) Pre. Ltd.
- "VLSI Fabrication Principles: Silicon and Gallium Arsenide", Wiley India (P) Ltd., New Delhi- 110 002.
- "VLSI Design Techniques for Analog and Digital Circuits", R. L. Geiger, P. E. Allen and N.R. Strader, Tata McGraw-Hill Education Private Limited, New Delhi- 100 008.
- "CMOS Digital Integrated Circuits- Analysis and Design", S. M. Kang and Y. Lablebici, Tata McGraw-Hill Private Limited, New Delhi- 110 095.
- "Basic VLSI Design", D. A. Pucknell and K. Eshraghian, PHI Learning Private Limited, New Delhi- 110 001.
- "Silicon VLSI Technology- Fundamentals, Practice and Modelling", J. D. Plummer, M. D. Deal and P. B. Griffin, Pearson India Education Services Pvt. Ltd., Noida- 201 309, India.

- Automatic Control Systems 8th edition– by B. C. Kuo 2003– John Wiley and son's.,
- Control Systems Engineering – by I. J. Nagrath and M. Gopal, New Age International (P) Limited, Publishers, 2nd edition.
- Modern Control Engineering – by Katsuhiko Ogata – Prentice Hall of India Pvt. Ltd., 3rd edition, 1998.
- *Control Systems Engineering*. by *P Ramesh Babu and* R *Anandanatarajan*, Scitech Publications (India) Pvt Ltd.
- Automatic Control System by S. Hasan Saeed, S.K. Kataria & Sons
- Electronic *Instrumentation and Measurement* by H S *Kalsi*, McGraw-Hill
- *Measurements and Instrumentation By A.K. Sawhney*, Dhanpat Rai & Co. (P) Limited.
- Integrated Electronics, Millman and Halkias.
- Electronics Principles, Malvino.

- Electronics Fundamental and Application, Chattopadhyay and Rakshit
- Application and Design of Analog Integrated Circuits, Jacob.
- Operational Amplifiers and Linear Integrated Circuits, Coughing and Discolt

Semester-IV

- "Microprocessor Architecture Programming and Applications with 8085", R. S. Gaonkar, Penram International Publishing (India) Pvt Ltd, Mumbai- 400 015.
- "The 8086 Microprocessor: Programming and Interfacing the PC", K. J. Ayala, Cengage Learning India Private Limited, Delhi- 110 092.
- "Microprocessors and Microcontrollers- Architecture, Programming and System Design 8085, 8086, 8051, 8096", K. Kant, Prentice-Hall of India Private limited, .
- "Microprocessor and Interfacing", D. V. Hall, Tata McGraw Hill Education.
- "Microcontrollers: Theory and Applications", A. V. Deshmukh, McGraw Hill Education (India) Pvt. Limited.
- Digital Signal Processing – Principles, Algorithms and Applications, J.G.Proakis & D.G.Manolakis, Pearson Ed.
- Digital Signal processing – A Computer Based Approach, S.K.Mitra, TMH Publishing Co.
- Digital Signal Processing Signals, Systems and Filters, A. Antoniou, TMH Publishing Co.
- Digital Signal Processing with Field Programmable Gate Arrays, U.Meyer-Baese, Springer
- Digital Signal Processing, P. Rameshbabu, Scitech Publications (India).
- Digital Signal Processing, S.Salivahanan, A.Vallabraj & C. Gnanapriya, TMH Publishing
- Digital Signal Processing; A Hands on Approach, C. Schuler & M.Chugani, TMH .
- Digital Signal Processing, A. Nagoor Kani, TMH Education
- Digital Signal Processing S. Poornachandra & B. Sasikala, MH Education
- Digital Signal Processing; Spectral Computation and Filter Design Chi-Tsong Chen,
- Oxford University Press
- Texas Instruments DSP Processor user manuals and application notes.
    a. Xilinx FPGA user manuals and application notes
- "Renewable Energy Sources and Emerging Technologies", D. P. Kothari, K. C. Signal and R. Ranjan, PHI Publication.
- "Non-Conventional Energy Resources", B. H. Khan, Tata McGraw Hill Publication.
- "Non-Conventional Energy Sources", G. D. Rai, Khanna Publishers, Delhi 110 033.
- Non-Conventional Energy Resources", S. N. Singh, Pearson, India.
- "Environmental Justice in India: The National Green Tribunal, G. N. Gill, Routledge Publication.
- "Environmental Impacts of Renewable Energy", F. R. Spellman, CPC Press.
- "Solar Cells: From Materials to Device Technology", Edited by S. K. Sharma and K. Ali, Springer Publication.

- "A Text Book of Nano Science and Technology", T. Pradeep, Tata McGraw Hill Education.
- "Textbook of Nano Science and Nanotechnology", B.S. Murty, P. Shankar, B. Raj, B.B. Rath and J. Murday, University Press.
- "Nanostructures and Nanomaterials- Synthesis, Properties and Applications", G. Cao, Imperial College Press, London.
- Introduction to Nano Science and Nanotechnology", G. L. Hornyak, H. F. Tibbals, J. Dutta and J. J. Moore, CRC press.
- "Nano:The Essentials Understanding Nano Science and Nano Technology", T. Pradeep, Tata McGraw Hill Education Pvt. Ltd., New Delhi.
- "Springer Handbook of Nanotechnology" Edited by B. Bhusan, Springer-Verlag.
- "Characterization of Materials, Vols. 1 & 2", E. N. Kaufmann, John Willey and Sons.
- "Introduction to Nanoscience and Nano technology", K. K. Chattopadhyay and A. N. Banerjee, PHI Learning Private Limited, New Delhi- 110 001.
- "An Introduction to Nanomaterials and Nanoscience", A. K. Das and M. Das, CBS Publishers and Distributors Pvt. Ltd., New Delhi.
- "Nanomaterials- Fabrication, Properties and Applications, U. Nandia and D. Jana, Tchno World, Kolkata- 700 007, India.
- Computer Data Communication, Williams
- Computer Networking, Tannunbam, PHI
- Power Electronics ',' N.Mohan, J.M. Undeland, and W.P. Robbins, John Wilay and Sons, 2003-2004.
- Power Electronics, M.D. Singh,K.B.Khanchandani, Tata McGraw Hill

- Computer Networks : Protocols, Standards and Interfaces, Black
- Local Area Network and their applications, Tangney and Omahony.
- Fiber optics and Optoelectronics, R.P. Khare, Oxford Press
- Optical Fiber Communication Principles and Systems, A. Selvarajan, S.Kar and T.Srinivas, TMH
- Optical Fiber Communications, Keiser, G. McGraw Hill, Int. Student Ed.
- Fiber Optic Communication systems, G.P.Aggarwal,Wiley Eastern
- Introduction to Fiber Optics , A.Ghatak and K.Thyagrajan, Cambridge Univ. Press
- Introduction to Optical Electronics, K.A. Jones, Harper & Row
- Principles and Applications of Optical communications, M.K.Liu, McGraw Hill