UNIVERSITY OF CALCUTTA

Notification No. CSR/80/2026

It is notified for information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in the exercise of his powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 17.07.2026, approved the Syllabus for semester-7 & 8 of 4-Year Honours & Honours with Research Courses of Studies in **Electronics including Question Patterns under CCF, 2022.**

The above shall take effect from the Odd Semester Examinations, 2026, and onwards.

22/07/2026

SENATE HOUSE
Kolkata-700073
22.07.2026

Prof.(Dr.) Debasis Das
Registrar

ELECTRONICS

SYLLABUS

B.SC.

(HONOURS AND HONOURS WITH RESEARCH)

FOUR-YEARS (EIGHT SEMESTERS)

DEGREE PROGRAM

IN

ELECTRONICS

SEMESTER – VII & VIII

UNDER CURRICULUM AND CREDIT FRAMEWORK-2022

(CCF-2022)

UNIVERSITY OF CALCUTTA

2026

The structure of the syllabus of Semesters 7 and 8 for the B.Sc. (Honours and Honours with Research) Course in Electronics. Each paper carries 4 Credits, equivalent to 100 marks.

DSCC/CC: Discipline Specific Core Course/Core Course (Major Course)

TH: Theory, P: Practical, TU: Tutorial, V: Viva Voce

4-Year B.Sc. Honours in Electronics

Semester	Paper Code	Course Code	Paper Name	Credit	Page No.
7	DSCC-16	ELTM-DSCC-16	Semiconductor Fabrication and Characterization	3TH+1TU	3, 4
	DSCC-17	ELTM-DSCC-17	Optical Fiber and Fiber Optic Communication	3TH+1TU	5, 6
	DSCC-18	ELTM-DSCC-18	Biomedical Instrumentation	3TH+1TU	6, 7
	DSCC-19	ELTM-DSCC-19	Artificial Intelligence and Machine Learning	3TH+1TU	8, 9
	DSCC-20	ELTM-DSCC-20	Electronics Laboratory I	4P	9, 10
8	DSCC-21	ELTM-DSCC-21	Digital Communication	3TH+1TU	10, 11
	DSCC-22	ELTM-DSCC-22	Computer Networking	3TH+1TU	12
	DSCC-23	ELTM-DSCC-23	Internet of Things (IoT)	3TH+1TU	13, 14
	DSCC-24	ELTM-DSCC-24	Electronics Laboratory II	4P	14
	DSCC-25	ELTM-DSCC-25	Project	3TH+1V	15

4-Year B.Sc. Honours with Research in Electronics

Semester	Paper Code	Course Code	Paper Name	Credit	Page No.
7	DSCC-16	ELTM-DSCC-16	Semiconductor Fabrication and Characterization	3TH+1TU	3, 4
	DSCC-17	ELTM-DSCC-17	Optical Fiber and Fiber Optic Communication	3TH+1TU	5, 6
	DSCC-18	ELTM-DSCC-18	Biomedical Instrumentation	3TH+1TU	6, 7
	DSCC-19	ELTM-DSCC-19	Artificial Intelligence and Machine Learning	3TH+1TU	8, 9
	DSCC-20	ELTM-DSCC-20	Electronics Laboratory I	4P	9, 10
8	RM-1	ELTM-RM-1	Research Methodology I	3TH+1V	15, 16
	RM-2	ELTM-RM-2	Research Methodology II	3TH+1V	16
	RI	ELTM-RI	Research Internship	3TH+1V	17
	RP	ELTM-RP	Research Project	6TH+2V	17

DSCC-16: Semiconductor Fabrication and Characterization
[Credits: 4 (3TH + 1TU)]

ELTM-DSCC-16-TH
Course Name: Semiconductor Fabrication and Characterization
[Credits: 3; Lecture Hours: 45]

Course Outcome (CO): After completion of the course, students will be able to:–
CO1: Learn different options available for growth of semiconductor devices.
CO2: Learn different steps in VLSI fabrication and the relative merits and demerits of the different options available for each stage of the process cycle.
CO3: Learn characterization technique to choose for obtaining a certain device/structural parameter.

UNIT–I [7 Lecture Hours]
Basics of Semiconductor Materials and Crystal Growth: Review of Energy Bands in Materials, Metal, Semiconductor and Insulator, Doping in Semiconductors, Defects, Point, Line, Schottky and Frenkel Defects.
Types of Solids: Single Crystal, Polycrystalline and Amorphous Materials, Common Semiconductor **Materials:** Silicon, Germanium, Compound Semiconductors (GaAs).
Crystal Growth Techniques: Need for Single Crystal Silicon in IC Fabrication, Czochralski Crystal Growth Technique, Float Zone Technique, Bridgman Crystal Growth Method.
Wafer Preparation: Wafer Slicing, Polishing and Cleaning.
Introduction to Semiconductor Technology: Evolution of Semiconductor Technology. Moore's Law, Overview of Technology Nodes such as 65 nm Node.

UNIT–II [12 Lecture Hours]
Epitaxy and Thin Film Deposition: Concept of Epitaxy, Epitaxial Growth, Importance in Device Fabrication.
Major Epitaxial Techniques: Vapor Phase Epitaxy (VPE) and Liquid Phase Epitaxy (LPE), Molecular Beam Epitaxy (MBE).
Basic Idea of Doping Distribution: Dopants in Semiconductors, Segregation during Crystal Growth (concept only).
Thin Film Growth Techniques and Processes: Basic Working Principle of Vacuum Pumps, Primary Pump (Mechanical) and Secondary Pumps (Diffusion, Turbo Molecular, Cryopump, Sputter Ion), Throughput and Characteristics in Reference to Pump Selection, Vacuum Gauges (Pirani and Penning), Sputtering, Evaporation (Thermal, Electron Beam), Pulse Laser Deposition (PLD), Chemical Vapor Deposition (CVD), Epitaxial Growth, Deposition by Molecular Beam Epitaxy (MBE).

UNIT–III [14 Lecture Hours]
Characterization of Semiconductor Materials:
Structural Characterization: Working Principle of X-Ray Diffraction (XRD), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM).
Surface Characterization: Working Principle of Atomic Force Microscope (AFM).
Optical Characterization: Working Principle of UV-Vis-NIR Spectroscopy.
Oxidation and Diffusion Processes:
Thermal Oxidation of Silicon: Thermal Oxidation Process, Dry and Wet Oxidation, Chemical Vapor Deposition of Silicon Oxide, Applications of Silicon Oxide.
Diffusion Process: Concept of Diffusion in Semiconductors, Diffusion Profiles (qualitative understanding), Lateral Diffusion.
Ion Implantation: Basic Principle, Advantages compared with Diffusion.

UNIT–IV [12 Lecture Hours]

VLSI Processing: Introduction to Microfabrication: Need for Clean Room, Clean Room Technology, Basic Contamination Control.

Optical Lithography: Photomasks, Photoresist, Pattern Transfer Process, Resolution Enhancement Techniques.

Advanced Lithography Techniques: Electron Beam Lithography, X-Ray Lithography, Ion Beam Lithography (working principle only).

Etching Techniques: Wet Chemical Etching, Basic Process and Examples of Etchants for Semiconductors, Insulators and Conductors, Dry Etching using Plasma Etching Technique.

Metallization in IC Fabrication: Purpose of Metallization Layers, Aluminium and Copper Interconnections.

Passive Components in IC: Integrated Resistors, Integrated Capacitors, Integrated Inductors (concept only).

Basic Device Fabrication Flow: Bipolar Device Fabrication (basic idea), MOSFET and CMOS Fabrication Processes.

Recommended Books:

- May and Sze, Fundamentals of Semiconductor Fabrication, Wiley.
- Campbell, Fabrication Engineering at the Micro and Nanoscale, Oxford University Press.
- Plummer, Deal and Griffin, Silicon VLSI Technology: Fundamentals, Practice and Modeling, Pearson.
- Eckertova, Physics of Thin Films, Springer.
- Weste and Harris, CMOS VLSI Design: A Circuits and Systems Perspective, Pearson.
- Ghandhi, VLSI Fabrication Principles: Silicon and Gallium Arsenide, Wiley.
- Sze, Semiconductor Devices: Physics and Technology, Wiley.
- Bose, IC Fabrication Technology, Tata McGraw Hill.
- Campbell, The Science and Engineering of Microelectronic Fabrication, Oxford University Press.
- Hu, Modern Semiconductor Devices for Integrated Circuits, Pearson.
- Plummer and Griffin, Integrated Circuit Fabrication: Science and Technology, Cambridge University Press.
- Schroder, Semiconductor Material and Device Characterization, Wiley.
- Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Wiley.
- Brandon and Kaplan, Microstructural Characterization of Materials, Wiley.

ELTM-DSCC-16-TU

Course Name: Semiconductor Fabrication and Characterization Tutorial

[Credit: 1; Tutorial Hours: 15]

Students must be given at least one assignment or a small set of problems from each Section. On the basis of regularity of submission and evaluation of assignment by the respective teacher, credits should be awarded to the students.

DSCC-17: Optical Fiber Communication
[Credits: 4 (3TH + 1TU)]

ELTM-DSCC-17-TH
Course Name: Optical Fiber Communication
[Credits: 3; Lecture Hours: 45]

Course Outcome (CO): After completion of the course, students will be able to:–
CO1: Explain the principles of light propagation and classify optical fibers by type and mode.
CO2: Differentiate between attenuation and dispersion mechanisms and their effects on signal quality.
CO3: Compare the structure and function of key components: cables, LEDs, lasers, and photodetectors.
CO4: Describe the architecture of a fiber optic link, including modulation, multiplexing, and design factors.
CO5: Identify various fiber optic sensors and their applications in measurement.

Unit–I [4 Lecture Hours]
Introduction and Concepts: Historical Developments, Basic Concept, Optical Fiber Communication System, Need and Advantages of Optical Fiber Communication, Classification of Fibers, Monomode and Multimode, Step-Index and Graded-Index, Plastic Fiber, Glass Fiber, Brief Overview of Specialty Fibers, HPSUV, HPSIR, Chalcogenide, Halide and Tapered Fibers.

UNIT–II [14 Lecture Hours]
Ray Transmission and Waveguide Principles in Optical Fibers: Ray Propagation in Step-Index and Graded-Index Fibers, Acceptance Angle, Numerical Aperture, Skew Rays, Goos–Haenchen Shift, Optical Fiber as Cylindrical Waveguide, Wave Equations in Step-Index (SI) Fibers, Modes in Step-Index Fibers, Power Flow in SI Fibers, Mode-Field Diameter and Spot Size, Effective Refractive Index, Fiber bandwidth.
Fiber Losses: Attenuation Coefficient, Absorptions, Linear Scattering Losses, Rayleigh Scattering and Mie Scattering, Nonlinear Scattering Losses, Stimulated Brillouin Scattering, Stimulated Raman Scattering, Bending Losses, Propagation Effect of Material Dispersion, Combined Effect of Multipath and Material Dispersion, Understanding of RMS Pulse Width, Bit Rate and Data Speed Limitations, Fiber Bandwidth.

UNIT–III [12 Lecture Hours]
Sources, Detectors and Connections: Light Sources for Optical Fibers, Light Emitting Diode (LED), Fiber LED Coupling, Bandwidth, Spectral Emission of LED, Laser, Laser Chirp, Light Emitting Transistor, Organic LED, Power Efficiency, Quantum Efficiency, Photo Detectors, Characteristics of Photodetectors, Photo-Emissive, Photo-Conductive, Photo-Voltaic Ddevices, PIN Photo Diode, Avalanche Photo Diode (APD), Bit Error Rate (BER) of Photodetector, Optical Fiber Cables and Connections, Fiber Material Requirements, Fiber Fabrication Methods, Fiber-Optic Cables, Optical Fiber Connections and Related Loses, Fiber Splices, Fiber-Optic Connectors, Characterization of Optical Fibers.

UNIT–IV [10 Lecture Hours]
Modulation and Multiplexing: Basic Concepts of Analog and Digital Modulation, Intensity Modulation (IM), Pulse Code Modulation (PCM), Multiplexing, Wavelength Division Multiplexing (WDM) and Dense WDM (DWDM), Fiber-Optic Communication System, System Design Consideration for Point-to-Point Links, System Architecture, Noise in Optical Receivers, Nonlinear Effects and System Performance, Dispersion Management, Local Area Networks (LAN), Optical Fiber Networks.

UNIT–V [5 Lecture Hours]
Optical Sensing and Applications: Fiber-Optic Sensors, Classification of Fiber-Optic Sensors, Intensity Modulated Sensors, Phase Modulated Sensors, Spectrally Modulated Sensors, Distributed Fiber-Optic Sensors.

ELTM-DSCC-17-TU
Course Name: Optical Fiber Communication Tutorial
[Credit: 1; Tutorial Hours: 15]
Students must be given at least one assignment or a small set of problems from each Section. On the basis of regularity of submission and evaluation of assignment by the respective teacher, credits should be awarded to the students.

Recommended Books:

- Senior, Optical Fiber Communications: Principles and Practice, Pearson.
- G, P. Agrawal, Fiber-Optic Communication Systems, Wiley India.
- Palais, Fiber Optic Communications, Pearson.
- Ghatak and Thyagarajan, Introduction to Fiber Optics, Cambridge University Press.
- Jha, Fiber Optic Technology - Applications to Commercial, Industrial, Military and Space Optical Systems, Printice Hall India.
- Khare, Fiber Optics and Optoelectronics' by Oxford University Press.
- Gupta, Textbook on Optical Communication and Its Applications, Printice Hall India.
- Sarkar, Optical Fibres and Fibre Optic Communication Systems, S. Chand & Co.

DSCC-18: Biomedical Instrumentation
[Credits: 4 (3TH + 1TU)]

ELTM-DSCC-18-TH
Course Name: Biomedical Instrumentation
[Credits: 3; Lecture Hours: 45]

Course Outcome (CO): After completion of the course, students will be able to:–
CO1: Explain the basic concepts of biomedical signals, electrodes, and physiological transducers used for measuring body parameters.
CO2: Describe the working principles of common patient monitoring systems such as ECG, blood pressure monitor, pulse oximeter, and audiometer.
CO3: Understand the basic principles of modern medical imaging systems including X-ray, CT, MRI, and ultrasound.
CO4: Explain the operation of major therapeutic and physiotherapy equipment such as pacemakers, defibrillators, dialysis machines, and diathermy units.
CO5: Identify electrical safety requirements and computer applications in biomedical instrumentation and hospital monitoring systems.

UNIT–I [10 Lecture Hours]
Biomedical Signals and Transducers: Types of Biomedical Signals – ECG, EEG, EMG (Basic idea), Origin of Bioelectric Signals (Heart, Brain, Muscle – Simple Physiology), Recording Electrodes – Surface and Needle Electrodes, Electrodes for ECG, EEG, EMG (Placement and Function).
Physiological Transducers: Pressure, Temperature (Thermistor), Photoelectric Sensor, Ultrasound Sensor, Basic Respiratory Measurement and Spirometer (Principle only).
ECG, EEG, EMG Machines – Block Diagram, Introduction to MEMS Biosensors (Wearable Health Devices – Overview).

UNIT–II [10 Lecture Hours]
Patient Monitoring Systems: Bedside Patient Monitor – Basic Block Diagram, Measurement of Heart Rate, Blood Pressure (Non-Invasive), Body Temperature, Respiration Rate, Arrhythmia Monitor (Basic concept), Pulse Oximeter (Principle of SpO2 Measurement), Blood Flow Measurement (Doppler Principle – Basic idea), Audiometer (Hearing Test Principle), Blood Gas Analyzer (Overview only).

UNIT–III [10 Lecture Hours]
Modern Imaging and Therapeutic Equipment: X-Ray Machine – Basic Principle, CT – Basic idea, MRI – Simple working concept, Ultrasonic Imaging – Basic Principle, Echocardiography – Overview.
Therapeutic Equipment (Principle Only): Cardiac Pacemaker, Defibrillator, Hemodialysis Machine, Surgical Diathermy.

UNIT–IV [10 Lecture Hours]
Patient Safety and Computer Applications: Electric Shock Hazards in Hospitals and Precautions to Minimize them, Effects of Electric Current on Human Body (Macroshock and Microshock), Leakage Current and Safety Precautions, Safety Codes for Biomedical Equipment (Overview), Electric Safety Analyzer (Basic Function), Testing and Calibration of Biomedical Equipment.
Computer Applications: Role of Microprocessors in Medical Instruments, Microcontrollers in Portable Medical Devices, PC based Medical Instruments, Basic idea of AI based Computerized ICU.

UNIT–V [5 Lecture Hours]
Physiotherapy Equipment: Shortwave Diathermy, Microwave Diathermy, Ultrasound Therapy, Electrotherapy (TENS – Basic idea), Ventilators (Basic working principle).

ELTM-DSCC-18-TU
Course Name: Biomedical Instrumentation Tutorial
[Credit: 1; Tutorial Hours: 15]
Students must be given at least one assignment or a small set of problems from each Section. On the basis of regularity of submission and evaluation of assignment by the respective teacher, credits should be awarded to the students.

Recommended Books:

- Carr and Brown, Introduction to Biomedical Equipment Technology, Pearson.
- Chatterjee, Biomedical Instrumentation System, Cengage.
- Khandpur, Handbook of Biomedical Instrumentation, Tata McGraw Hill.
- Natarajan, Biomedical Instrumentation and Measurements, PHI.
- Jacobson and Webster, Medicine and Clinical Engineering, Prentice Hall.
- Venkata Ram, Biomedical Electronics and Instrumentation, Galgotia.
- Webster, Medical Instrumentation: Application and Design, Wiley.
- Cromwell, Biomedical Instrumentation and Measurements, Pearson.

DSCC-19: Artificial Intelligence and Machine Learning
[Credits: 4 (3TH + 1TU)]

ELTM-DSCC-19-TH
Course Name: Artificial Intelligence and Machine Learning
[Credits: 3; Lecture Hours: 45]

Course Outcome (CO): After completion of the course, students will be able to:–
CO1: Learn fundamental concepts related to Machine Learning.
CO2: Execute Data Preprocessing and Visualisation.
CO3: Implement and Evaluate Predictive Regression Models,
CO4: Construct and Assess Classification Systems.
CO5: Apply Unsupervised Learning for Pattern Discovery.
CO6: Evaluate Emerging Trends and Ethical Constraints.

UNIT-I [6 Lecture Hours]
Introductory Concept: What is Machine Learning? Human Learning versus Machine Learning, Relationship between Artificial Intelligence, Machine Learning and Deep Learning, Concept of Data, Data-Driven Decision Making, Supervised Learning (Predicting Labels), Unsupervised Learning (Finding Patterns), and a Brief Overview of Reinforcement Learning (Learning by Trial and Error), Applications of Machine Learning in Electronics, Communication Systems, Healthcare Devices, Smart Manufacturing, Autonomous Systems, and Consumer Electronics.

UNIT-II [7 Lecture Hours]
Data Handling and Visualisation: Types of Data, Numerical, Categorical, Image, Audio, and Sensor Data; Data Representation using Tables and Matrices, Data Collection, Preprocessing, Handling Missing Values, Normalisation, Scaling, and Encoding Categorical Data, Feature Extraction, Training, Testing, and Deployment; Data Visualisation using Graphs and Plots, Understanding Trends, Patterns, and Correlations in Data; Simple Statistical Concepts useful in ML: Mean, Median, Mode, Variance, and Standard Deviation, Training-Validation-Testing Split.

UNIT-III [10 Lecture Hours]
Regression and Predictive Modelling: Predicting Values using Simple Linear Regression (Fitting a Straight Line to Data), Concept of Cost Function (Mean Squared Error) and Gradient Descent, R-Squared Score; Binary and Multi-Class Classification, Logistic Regression for Binary Classification, the Sigmoid Function and Decision Boundaries. Simple Applications.

UNIT-IV [10 Lecture Hours]
Pattern Recognition and Classification: K-Nearest Neighbors (K-NN), Distance Metrics, Decision Trees, Understanding Nodes, Roots and Trees, Classification Accuracy, Confusion Matrix; Simple Applications in Electronics such as Temperature Prediction, Signal Classification, and Fault Detection.

UNIT-V [7 Lecture Hours]
Unsupervised Learning and Clustering: K-Means Clustering, Application in Anomaly Detection, Concept of Dimensionality Reduction, Basic Idea of Principal Component Analysis (PCA) without Mathematical Derivation. Simple Applications.

UNIT-IV [5 Lecture Hours]
Future Trends and Ethical Aspects: Concept of Artificial Neural Networks and Deep Learning; Concept of TinyML, Edge AI and their Real World Applications; Ethical Aspects of AI and ML including Bias, Fairness, Privacy, Security, and Responsible use of Data.

ELTM-DSCC-19-TU
Course Name: Artificial Intelligence and Machine Learning Tutorial
[Credit: 1; Tutorial Hours: 15]
Students must be given at least one assignment or a small set of problems from each Section. On the basis of regularity of submission and evaluation of assignment by the respective teacher, credits should be awarded to the students.

Recommended Books:
- Alpaydin, Introduction to Machine Learning' (Indian Edition), Prentice Hall of India/MIT Press.
- Sridhar and Vijayalakshmi, Machine Learning, Oxford University Press India.
- Srinivasaraghavan and Joseph, Machine Learning, Wiley India.
- Mitchell, Machine Learning, McGraw Hill Education (India).
- Chopra, Machine Learning, Khanna Publishing House, India.
- Pujari, Machine Learning and Data Science: An Introduction, CRC Press/Taylor & Francis India.

DSCC-20: Electronics Laboratory I
[Credits: 4P]

ELTM-DSCC-20-P
Course Name: Electronics Laboratory I
[Credits: 4; Practical Hours: 120]

Group-A (50 Marks)

UNIT-I: Semiconductor Fabrication and Characterization Lab

1. Indexing of XRD Peaks using Standard Data.
2. Determination of d-Spacing/Lattice Constant from the XRD Pattern.
3. Determination of Crystallite Size from the XRD Pattern using Scherrier Formula.
4. Determination of Optical Bandgap using UV-VIS-NIR Transmittance Spectra from Published literature.

UNIT-II: Optical Fiber Communication Lab
Use Scilab Simulations Software to perform the following experiments.

1. To Determine Characteristics of LEDs and Photo-Detector.
2. To Measure the Numerical Aperture (NA) and Maximum Acceptance Angle (θ) for a Step-Index Fiber and Visualize the Acceptance Cone.
3. To Plot the Wavelength Dependent Attenuation due to Rayleigh Scattering in Silica Fiber in the Wavelength Range 400 nm to 1600 nm.
4. To Visualize Ray Propagation in a Step-Index Fiber showing Confinement via Total Internal Reflection.
5. To Simulate a simple WDM Spectrum with 4 Channels and visualize the effect of Channel Crosstalk.
6. To Simulate the Exponential Increase in Attenuation as a Function of a Physical Parameter (e.g., Displacement/Pressure inducing Bending).

Group-B (50 Marks)

UNIT-I: Biomedical Instrumeation Lab

1. Study of Bio-Potential Amplifier (ECG).
2. ECG Simulator Study.
3. Heart Rate Measurement using ECG/Pulse Monitor.
4. Pulse Rate Monitor with Alarm.
5. Respiration Rate Measurement using Thermistor.
6. Pulse Rate Measurement using Photoelectric Sensor.

UNIT-II: Artificial Intelligence and Machine Learning Lab
(Use Python and its libraries NumPy, Pandas, Matplotlib and Scikit-Learn)

1. Load a CSV dataset containing synthetic multi-sensor readings (e.g., temperature, pressure, etc.). Compute basic statistical metrics like mean, median and standard deviation). Plot the relevant scatter plots, histograms, and time-series line charts to portray the data distributions.
2. Generate a simulated CSV dataset containing voltage and current readings (dc or ac rms) from circuit components like a resistor, inductor and a capacitor. Purposefully introduce missing values in the dataset. Load the data set, clean missing values and plot standard V-I characteristic curves for each component.
3. Generate a dataset for a Light Dependent Resistor (either synthetic or from an experiment) where resistance varies with lux (luminous flux per unit area). Perform a log-log transformation of the data before fitting a linear regression line to predict lux based on any measured resistance. Plot the scatter data alongside the regression line.
4. Train a Multiple Linear Regression model on a dataset mapping raw ADC (Analog-to-Digital Converter) counts from physical sensors to actual physical units (e.g., Thermistor counts --> Temperature in °C). Evaluate using R2 score and Mean Absolute Error (MAE).
5. Train a Decision Tree classifier to predict whether a resistor is defective (Pass or Fail) based on two parameters: nominal resistance deviation and ambient temperature during testing. Generate the required data sets synthetically before testing. Plot the resulting tree layout.
6. Use an unlabelled dataset of LED manufacturing outputs, varying in dominant wavelength and forward voltage (the data may be generated synthetically). Apply K-Means to automatically sort them into 3 bin categories, namely, Premium, Standard and Defective.

DSCC-21: Digital Communication
[Credits: 4 (3TH + 1TU)]

ELTM-DSCC-21-TH
Course Name: Digital Communication
[Credits: 3; Lecture Hours: 45]

Course Outcome (CO): After completion of the course, students will be able to:–
CO1: Analyze signal representation, probability and random process in signal transmission.
CO2: Describe the concepts of sampling, quantisation, Pulse Modulation techniques, different types of source encoding techniques and their properties.
CO3: Undersatand various types of coherent digital modulation techniques and calculate their error probabilities.
CO4: Analyze the signal detection framework for optimal correlator receiver design for digital transmission under additive white Gaussian channel noise.
CO5: Understand the fundamentals of source and channels error correction coding and evaluate efficiency of source information and rate of information transmission over noisy channel.

UNIT-I [8 Lecture Hours]
Fundamentals and Signal Representation: Review of Random Processes, Power Spectral Density (PSD), Autocorrelation, White Gaussian Noise (WGN), and Filtering through LTI systems.
Geometric Representation of Signals: Signal Space Concepts, Gram-Schmidt Orthogonalization, and Orthonormal basis functions.
Sampling and Quantization: Low-Pass and Band-Pass Sampling Theorems, Aliasing, Uniform and Non-Uniform Quantization, A-Law and μ-Law (mu-Law) Companding.

UNIT-II [8 Lecture Hours]
Source Coding and Waveform Coding: Information Theory: Entropy, Source Coding Theorem, Huffman Coding, and Shannon-Fano Coding.
Pulse Code Modulation (PCM): Generation and Reconstruction, Quantization Noise, and Bandwidth Requirements.

Differential Encoding: Differential Pulse Code Modulation (DPCM), Delta Modulation (DM), and Adaptive Delta Modulation (ADM).

UNIT-III [8 Lecture Hours]
Digital Modulation Techniques: Baseband Transmission, Line Coding (NRZ, RZ, Manchester), Inter-Symbol Interference (ISI), Nyquist Criterion for Distortionless Baseband Transmission, and Raised Cosine Filters.
Passband Modulation: Binary Schemes: ASK, FSK, PSK, and DPSK.
M-Ary Schemes: QPSK, M-Ary PSK, and M-Ary QAM.
Advanced: Orthogonal Frequency Division Multiplexing (OFDM).

UNIT-IV [8 Lecture Hours]
Signal Detection and Optimal Receivers: Optimal Receivers: Matched Filter, Correlation Receiver, and Maximum Likelihood (ML) Detection.
Performance Analysis: Probability of Error (P_e) and Bit Error Rate (BER) calculations for various Modulation Schemes in AWGN Channels.
Synchronization: Carrier Phase Recovery, Symbol Timing and Frame Synchronization.

UNIT-V [8 Lecture Hours]
Error Control Coding (Channel Coding): Linear Block Codes: Hamming Codes, Cyclic Redundancy Check (CRC), and Syndrome Decoding.
Convolutional Codes: Code Tree, Trellis Diagrams, and Viterbi Algorithm.
Channel Capacity: Shannon-Hartley Theorem and limits of Communication.

UNIT-VI [5 Lecture Hours]
Spread Spectrum and Multi-Access: Spread Spectrum: Direct Sequence Spread Spectrum (DSSS) and Frequency Hopping Spread Spectrum (FHSS).
Multiple Access: TDMA, FDMA, and CDMA.

ELTM-DSCC-21-TU
Course Name: Digital Communication Tutorial
[Credit: 1; Tutorial Hours: 15]
Students must be given at least one assignment or a small set of problems from each Section. On the basis of regularity of submission and evaluation of assignment by the respective teacher, credits should be awarded to the students.

Recommended Books:

- Proakis and Salehi, Digital Communications, McGraw-Hill.
- Lee and Messerschmitt, Digital Communication, Springer.
- Sklar, Digital Communications: Fundamentals and Applications, Prentice Hall.
- Rao, Principles of Digital Communication, Tata McGraw-Hill Education.
- Sharma, Digital Communication, S.K. Kataria & Sons.
- Lathi and Ding, Modern Digital and Analog Communication Systems, Oxford University Press India.
- Rajasekar, Digital Communications, New Age International Publishers.

DSCC-22: Computer Networking
[Credits: 4 (3TH + 1TU)]

ELTM-DSCC-22-TH
Course Name: Computer Networking
[Credits: 3; Lecture Hours: 45]

Course Outcome (CO): After completion of the course, students will be able to:–
CO1: Explain the fundamental principles of data communication, network edge/core dynamics, and reference models.
CO2: Analyze the operation of major application layer protocols and design simple network applications.
CO3: Differentiate between connectionless and connection-oriented transport and evaluate mechanisms for congestion control and reliable data transfer.
CO4: Implement IPv4 addressing schemes and solve complex routing problems.
CO5: Analyze error-detection techniques and multiple access protocols.

UNIT-I [9 Lecture Hours]
Foundations: Network Edge, Network Core, Packet Switching vs Circuit Switching, Delay, Loss, and Throughput, Protocol Layers, and Service Models (OSI and TCP/IP).

UNIT-II [9 Lecture Hours]
Application Layer: Principles of Network Applications, Web and HTTP, FTP, Electronic Mail (SMTP, POP3, IMAP), DNS, and P2P Applications.

UNIT-III [9 Lecture Hours]
Transport Layer: Multiplexing and Demultiplexing, Connectionless Transport (UDP), Principles of Reliable Data Transfer, Connection-Oriented Transport (TCP), Congestion Control, and TCP Segment Structure.

UNIT-IV [9 Lecture Hours]
Network Layer: Virtual Circuit and Datagram Networks, IP Protocol, IPv4/IPv6 Addressing, ICMP, Routing Algorithms (Link State, Distance Vector), and Hierarchical Routing, Software-Defined Networking (SDN).

UNIT-V [9 Lecture Hours]
Link Layer and Local Area Networks: Error-Detection and Correction Techniques, Multiple Access Links and Protocols (CSMA/CD, CSMA/CA), Ethernet, Switches, and Wireless Links (802.11), VLANs.

ELTM-DSCC-22-TU
Course Name: Computer Networking Tutorial
[Credit: 1; Tutorial Hours: 15]
Students must be given at least one assignment or a small set of problems from each Section. On the basis of regularity of submission and evaluation of assignment by the respective teacher, credits should be awarded to the students.

Reference Books:

- Computer Networking: A Top-Down Approach' by James F. Kurose and Keith W. Ross, Pearson Education.
- Forouzan, Data Communications and Networking, McGraw Hill Education.
- Tanenbaum and Wetherall, Computer Networks, Pearson.
- Sharma, Computer Networks (An Engineering Approach), S. K. Kataria & Sons.
- Singh, Data Communications and Computer Networks, Prentice Hall India.

DSCC-23: Internet of Things (IoT)
[Credits: 4 (3TH + 1TU)]

ELTM-DSCC-23-TH
Course Name: Internet of Things (IoT)
[Credits: 3; Lecture Hours: 45]

Course Outcome (CO): After completion of the course, students will be able to:–
CO1: Explain Introduce the concept of Internet of Things (IoT).
CO2: Understand basic IoT architecture and devices.
CO3: Learn to interface simple sensors and actuators.
CO4: Build small IoT applications using affordable hardware.
CO5: Understand basic IoT communication and cloud concepts.

UNIT-I [7 Lecture Hours]
Introductory Concepts: What is IoT? Evolution of IoT, Applications of IoT (Smart Homes, Industrial Automation, Wearable Health Devices, Smart Cities, Agriculture, and Supply Chain Logistics), IoT Ecosystem, IoT vs Traditional Embedded sstems.

UNIT-II [10 Lecture Hours]
IoT Architecture and Devices: Microcontrollers and their Difference with Microprocessors, SoC (System on Chip) Architecture (Basic Idea), IoT Architecture Layers (Perception Layer, Network Layer, Application Layer), Sensors and Actuators, Embedded Systems in IoT, Power and Energy Considerations, Example Devices like Arduino Uno, ESP8266, Raspberry Pi 4 (Basic idea and Programming Environment: Arduino IDE versus Python/Linux for Pi).

UNIT-III [10 Lecture Hours]
Sensors and Interfacing: Types of Sensors, Analog versus Digital Sensors, Sensor Interfacing Basics, Actuators and Relays, LEDs, Buzzers, Relays, and Small DC Motors, Example Sensors like LDR, Temperature and Humidity Sensors (Working idea), I2C, SPI, and UART Protocols (Basic idea).

UNIT-IV [10 Lecture Hours]
Communication Technologies related to IoT: Basics of Wireless Communication, IoT Communication Protocols like MQTT and HTTP, WiFi, Bluetooth and ZigBee (Basic idea), Cloud Platforms like ThingsBoard, Blynk, or Arduino IoT Cloud (Basic idea).

UNIT-V [8 Lecture Hours]
IoT Security and Future Trends: Basic IoT Security Challenges, Data Privacy, Device Authentication, Future Trends in IoT, Basic idea of AI and IoT (AIoT), Over-the-Air" (OTA) Updates, Concept of 'Digital Twins'.

ELTM-DSCC-23-TU
Course Name: Internet of Things (IoT) Tutorial
[Credit: 1; Tutorial Hours: 15]
Students must be given at least one assignment or a small set of problems from each Section. On the basis of regularity of submission and evaluation of assignment by the respective teacher, credits should be awarded to the students.

Recommended Books:

- Bahga and Madisetti, Internet of Things: A Hands-On Approach, Universities Press (Orient Blackswan).
- Raj Kamal, Internet of Things: Principles and Paradigms, McGraw Hill Education (India).

• Raj and Raman, The Internet of Things: Enabling Technologies, Platforms, and Use Cases, CRC Press/Taylor & Francis.
• Prabhu and Satya Murty, IoT and Smart Systems, Oxford University Press India.
• Hanes, Salgueiro, Grossetete, Barton and Henry, IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, Pearson India.
• Prasad, Embedded Systems and IoT with Arduino and Raspberry Pi, Dreamtech Press.

DSCC-24: Electronics Laboratory II
[Credits: 4P]

ELTM-DSCC-24-P
Course Name: Electronics Laboratory II
[Credits: 4; Practical Hours: 120]

Group-A
UNIT-I: Digital Communication Lab
Use SCILAB Simulation Software to perform the following Practical Experiments.

1. Sampling Theorem: Verification of Nyquist Rate and Reconstruction of Signals.
2. Waveform Generation: Implementation of PCM and Delta Modulation.
3. Digital Keying: Designing ASK, FSK, and PSK Modulators/Demodulators.
4. Error Correction: Simulation of Linear Block Codes and Cyclic Codes.
5. Effect of Noise, Eye Diagram.

UNIT-II: Computer Networking Lab

1. Packet Sniffing and Protocol Analysis: Use 'Wireshark' to Capture and Analyze Network Traffic.
2. Socket Programming: Develop a Simple Client-Server Application, such as a Chat Application, using Python or C++ to understand how the Application Layer Interfaces with the Transport Layer.
3. Network Configuration and Simulation: Use tools like 'Cisco Packet Tracer' or 'GNS3' to design a small-scale enterprise network, Configure IP addresses, and implement static or dynamic routing.
4. Network Performance Analysis: Measure the Impact of Latency and Packet Loss on File Transfer Speeds using Tools like 'ping', 'traceroute' and 'iperf'.

Group-B
Internet of Things (IoT) Lab
Use Arduino Uno, Raspberry Pi 4 or ESP32/ESP8266 to perform the following experiments.

1. Using Pulse Width Modulation (PWM) for Dimming LEDs.
2. Using Pulse Width Modulation (PWM) for Controlling dc Motor Speed.
3. Using a Relay Module to Control a High-Voltage Appliance like a Desk Lamp.
4. Reading an Analog Light Sensor e.g., LDR and Displaying Data on a Serial Monitor.
5. Reading a Digital Temperature Sensor DHT11 and Displaying Data on a Serial Monitor.
6. Connecting the ESP32/ESP8266 to Local Wi-Fi and Fetching Time/Weather Data.
7. Measuring Distance using an Ultrasonic Sensor like HC-SR04.
8. Sending Sensor Data to a Cloud Dashboard via MQTT.

ELTM-DSCC-25: Project
[Credits: 3TH + 1V]

ELTM-DSCC-25-TH
Course Name: Project
[Credits: 3; Project Hours: 90]

ELTM-DSCC-25-V
Course Name: Project Viva Voce
[Credit: 1]

The detailed guideline will be made available later.

ELTM-RM-1: Research Methodology I
[Credits: 3TH + 1V]

ELTM-RM-1-TH
Course Name: Research Methodology I
[Credits: 3; Lecture Hours: 45]
ELTM-RM-1-V
Course Name: Research Methodology I Viva Voce
[Credit: 1]

Course Outcome (CO): After completion of the course, students will be able to:
CO1: Understand the basic concepts and significance of research.
CO2: Identify research problems and explain the steps of the research process.
CO3: Acquire basic knowledge of research design, sampling and data collection methods.
CO4: Recognize ethical issues in research and maintain academic integrity.
CO5: Conduct a basic literature review and use appropriate citation and referencing methods.
CO6: Develop basic skills for academic research and report preparation.

UNIT-I [Lecture Hours: 20]
Fundamentals of Research, Research Process and Research Design: Meaning, Definition and Significance of Research; Objectives and Types of Research (Basic, Applied, Qualitative and Quantitative). Characteristics of Good Research. Identification and Formulation of Research Problems; Sources of Research Problems; Formulation of Research Objectives and Hypothesis. Concept of Research Methodology and Research Methods. Steps in Research Process: Problem Identification, Literature Survey, Research Design, Data Collection, Data Analysis, Interpretation and Report Writing. Meaning and Importance of Research Design; Types of Research Design – Exploratory, Descriptive and Experimental. Basic Concepts of Population and Sample; Introduction to Sampling Techniques (Random and Non-Random). Methods of Data Collection – Primary and Secondary Data, Questionnaire, Interview and Observation. Basic Idea of Data Classification, Tabulation and Interpretation. Structure and Components of Research Report.

UNIT-II [10 Lecture Hours]
Research Ethics and Social Impact: Concept and Importance of Research Ethics, Ethical Responsibilities of Researchers, Academic Integrity. Plagiarism and its Consequences; Methods to Avoid Plagiarism; Importance of Proper Citation and Acknowledgement of Sources. Responsible use and Reporting of Research Data. Social Relevance of Research; Role of Research in Societal Development; Environmental and Social Implications of Scientific and Technological Research.

UNIT-III [10 Lecture Hours]
Literature Review: Meaning and Purpose of Literature Review; Importance of Literature Review in Research Planning. Sources of Literature – Books, Research Journals, Conference Proceedings, Dissertations, Theses and Online Databases. Techniques of Searching Academic Literature using Digital Platforms. Reading, Summarizing and Organizing Research Articles; Identification of Research Gaps. Basics of Citation and Referencing Styles (APA, MLA and Chicago); Introduction to Reference Management Tools.

ELTM-RM-2: Research Methodology II
[Credits: 3TH + 1V]

ELTM-RM-2-TH
Course Name: Research Methodology II
[Credits: 3; Lecture Hours: 45]
ELTM-RM-2-V
Course Name: Research Methodology II Viva Voce
[Credit: 1]

Course Outcome (CO): After completion of the course, students will be able to:–
CO1: Learn the basic research methods used in scientific investigations.
CO2: Familiarize with common techniques and tools used in research practice.
CO3: Develop understanding of academic citation, referencing, and bibliography preparation.
CO4: Promote responsible scholarly communication and proper acknowledgement of sources.

UNIT-I [16 Lecture Hours]
Research Methodological Frameworks: Overview of Qualitative vs. Quantitative Designs (Surveys, Experiments, Case Studies); Understanding the Difference between Research Methodology and Research Methods; Problem Formulation: Formulating Research Problems Specific to Electronics (e.g., Circuit Efficiency, Signal Processing Accuracy); Data Planning: Planning Data Collection and Analysis.
Research Methods: Brief Description of Qualitative and Quantitative Research Methods, Mixed Research Methods Combining Qualitative and Quantitative Approaches; In-Class Exercise: Drafting Mini-Research Plan Defining Specific Variables (Independent/Dependent) and Selected Methods.

UNIT-II [14 Lecture Hours]
Organizational Techniques: Concept of Research Techniques and Tools; Use of Concept Mapping for Organizing Complex Engineering Ideas and System Architectures.
Data Analysis Tools: Introduction to Industry-Standard Tools for Electronics Research including Excel for Basic Statistics, and Python or MATLAB for Advanced Signal Analysis and Visualization; Writing and Publishing Tools: Desktop-Publishing Tools with Focus on LaTeX (Standard for Technical Papers) versus MS Word; Reference Management: Use of Reference Managers (Zotero, EndNote, Mendeley) to Automate Research Workflow; In-Class Exercise: Conduct a Live Demo of Zotero Library Import and Automated Citation Insertion into Document.

UNIT-III [15 Lecture Hours]
Citation and Bibliography: Concept and Importance of Citation in Academic Research; Acknowledging Sources and Avoiding Plagiarism; Integrity Standards: Overview of University Plagiarism Policies and Academic Integrity; Discussing the Consequences of Plagiarism with Real-World Case Examples in the Engineering Field; Formatting Styles: IEEE Style (IEEE Standard for Electrical Engineering), Chicago and APA Styles: Basic Features and Comparative Overview; Technical Writing Skills: Proper Paraphrasing and Quotation Techniques to Maintain Technical Accuracy without Verbatim Copying; Bibliography Construction: Importance of Citing all Sources (Books, Journal Articles, Book Chapters, and Online Sources); Conversion of a given Reference between Styles; Preparation of a Final Bibliography and Reference List.

ELTM-RI: Research Internship
[Credits: 3TH + 1V]

ELTM-RI-TH
Course Name: Research Internship
[Credits: 3]

ELTM-RI-V
Course Name: Research Internship Viva Voce
[Credit: 1]

The detailed guideline will be made available later.

ELTM-RP: Research Project
[Credits: 6TH + 2V]

ELTM-RI-TH
Course Name: Research Project
[Credits: 6]

ELTM-RI-V
Course Name: Research Project Viva Voce
[Credits: 2]

The detailed guideline will be made available later.

Question Pattern

Theory: Full Marks: 75 (Duration: 3 Hours) [Credits 3]

Major papers ELTM-DSCC-16, ELTM-DSCC-17, ELTM-DSCC-18, ELTM-DSCC-19, ELTM-DSCC-21, ELTM-DSCC-22, and ELTM-DSCC-23 of Semesters 7 and 8 with 3 credits for Theory will have the following structure:

Students have to answer 10 questions (out of 12) each of 2 marks, 3 questions (out of 5) each of 5 marks, and 4 questions (out of 7) each of 10 marks (part marks not more than 6).

[Total marks for the paper: $10\times2+3\times5+4\times10 = 75$]

Questions will be from the entire syllabus (covering all the units) commensurate with the number of lecture hours per unit.

ELTM-RM-1 and ELTM-RM-2

Theory: Full Marks: 75 [Credits 3]

Students have to answer 10 questions (out of 12) each of 1 mark, 10 questions (out of 12) each of 2 marks, 3 questions (out of 5) each of 5 marks, and 3 questions (out of 5) each of 10 marks.

[Total marks for the paper: $10\times1+10\times2+3\times5+3\times10 = 75$]

Questions will be from the entire syllabus (covering all the units) with commensurate with the number of lecture hours per unit.

Practical:

For Major papers ELTM-DSCC-20 and ELTM-DSCC-24 of Semesters 7 and 8 with 4 credits for Practical (Laboratory) component, the division of marks will be as follows:

ELTM-DSCC-20

Full Marks: 100 [Credits 4]

Group A: Full Marks: 50

Unit-I: Full Marks: 25 (Duration: 3 Hours)

Students have to perform one experiment from Unit-I in the end-semester examination.

Unit-II: Full Marks: 25 (Duration: 3 Hours)

Students have to perform one experiment from Unit-II in the end-semester examination.

Group B: Full Marks: 50

Unit-I: Full Marks: 25 (Duration: 3 Hours)

Students have to perform one experiment from Unit-I in the end-semester examination.

Unit-II: Full Marks: 25 (Duration: 3 Hours)

Students have to perform one experiment from Unit-II in the end-semester examination.

The division of marks of each unit of each group will be as follows:

Laboratory Notebook: 5, Viva-Voce: 5, Experiment (including Programming): 15

[Total marks for the paper: $(5+5+15)\times4 = 100$]

ELTM-DSCC-24 (Full Marks: 100)

Group A: Full Marks: 50

Unit-I: Full Marks: 25 (Duration: 3 Hours)

Students have to perform one experiment from Unit-I in the end-semester examination.

Unit-II: Full Marks: 25 (Duration: 3 Hours)

Students have to perform one experiment from Unit-II in the end-semester examination.

The division of marks of each unit of group A will be as follows:

Laboratory Notebook: 5, Viva-Voce: 5, Experiment (including Programming): 15

Group B: Full Marks: 50 (Duration: 6 Hours)

Students have to perform two experiments from group B in the end-semester examination.

The division of marks will be as follows:

Laboratory Notebook: 10, Viva-Voce: 10, Experiment (including Programming): 15+15

[Total marks for the paper: $(5+5+15)\times2 + (10+10+15+15) = 100$]

Tutorial: Full Marks: 25 [Credit 1]

For all Major papers with 1 credit (25 marks) Tutorial component, 15 marks will be awarded on the basis of regularity of submission and evaluation of assignment or a small set of problems, as mentioned in the syllabus and 10 marks will be awarded conducting a Viva-Voce examination by the respective teacher of the Electronics department of the concerned College.