

Indicative Syllabus (April 2026)

Common topics: Student can choose any two of the following, according to her/his preference

i. Linear Algebra: Matrix Algebra, Systems of linear equations, Eigenvalues and Eigenvectors, Fundamental Subspaces

ii. Calculus: Mean value theorems, Theorems of integral calculus, Evaluation of definite and improper integrals, Partial Derivatives, Maxima and minima, Fourier series, and multiple integrals.

iii. Differential equations:

iv. Probability and Statistics: Sampling theorems, Conditional probability, Joint Probability, Random variables, Discrete and continuous distributions, Uniform, Poisson, Normal and Binomial distribution, Evaluating expectations, conditional expectations.

v. Transform Theory: Fourier transform, Laplace transform, Z-transform, properties of these transforms, Parseval's theorem

Broad research areas:

- **Nanophotonics and Metamaterials (Computation and Experiment)**
- **Wireless communication & Sensing; Wireless systems implementation (RF frontend, FPGA, SDR, GPUs)**
- **Computational Nanoelectronics & Spintronics**
- **FPGA and System on Chip**
- **Machine Learning, Quantum Computing**
- **RF and Antenna Design**
- **DL and Agentic AI for building solutions**
- **Optimization, learning and Control**
- **Hardware Security, System on Chip**
- **Electronic Design Automation**
- **Optical wireless communication, Non-terrestrial networks**
- **Neuromorphic computing, spintronic and electronic devices (Experiments and Simulation)**

Specific topics for broad research areas:

- **Wireless communication & sensing; Wireless systems implementation (RF frontend, FPGA, SDR, GPUs)**
- **Optical wireless communication, Non-terrestrial networks**

Random signals and noise: probability, random variables, probability density function, autocorrelation, power spectral density.

Digital communication systems: Source coding, Entropy, Kraft's inequality, pulse code modulation (PCM), differential pulse code modulation (DPCM), digital modulation/demodulation schemes: amplitude, phase, and frequency-shift keying schemes (ASK, PSK, FSK). Higher-order modulation schemes: QAM vs QPSK, advantages, disadvantages.

Wireless Communication Systems: Fading (fast/slow/frequency selective/flat etc.), propagation models, path-loss, basics of mobile communication generations. Cellular and Wi-Fi standards.

Signals and Systems: LTI systems, Convolution, Fourier analysis, Sampling
Statistical Signal Processing: Likelihood, Linear Estimators, MMSE, Hypothesis testing, NP criterion

Machine Learning: Supervised and unsupervised learning, Regression, Classification, Clustering, Dimensionality reduction

Probability: Random variable, conditional probability, expectation, variance, pmf, pdf, cdf, typical random variables (Bernoulli, binomial, geometric, uniform, exponential, Gaussian), independence, Markov & Chebyshev inequality

Communication systems: Basic understanding of the following: modulation schemes, OFDM, MIMO, information theory, wireless channel, components of a wireless system, and the Internet.

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- **Machine Learning, Quantum Computing**
 - **DL and Agentic AI for building solution**

Signals and Systems: LTI systems, Convolution, Fourier analysis, Sampling, Fourier series, Fourier Transform, DFT, Convolution, LTI systems, sampling theorem

Linear Algebra: Matrix Algebra, Systems of linear equations, Eigenvalues and Eigenvectors, Fundamental Subspaces
Statistical Signal Processing: Likelihood, Linear Estimators, MMSE, Hypothesis testing, NP criterion

Machine Learning: Supervised and unsupervised learning, Regression, Classification, Clustering, Dimensionality reduction, being able to clearly explain any hands-on experience with machine learning/deep learning
Random signals and noise: Random Processes, autocorrelation, power spectral density.

Probability: Common PDF/PMFs, Bayes' Theorem, Conditional probability, basic concepts of random variables, expectation

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- **FPGA and System on Chip**
 - **Hardware Security, System on Chip**

Embedded and VLSI: Verilog, CPU Architecture, Pipelining

Digital Circuits: Boolean Algebra, CMOS inverter, Flip-flops, Combinational and Sequential Circuits, Counters, FSMs

Signals and Systems: LTI Systems, Fourier Transform, Convolution, and Correlation

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- **Neuromorphic computing, spintronic and electronic devices (Experiments and Simulation)**

Electromagnetics: Standard undergraduate topics in electromagnetism, including electric fields, magnetic fields, potential, electromagnetic waves, Maxwell equations, and impedance matching.

Semiconductor and magnetic fundamental: Energy band diagram, effective mass, carrier transport, Hall effects, p-n junctions, tunneling mechanisms, types of magnetism (para, ferro, antiferro, etc.), hysteresis loops, domain theory, introduction to magnetoresistance.

Electrical circuits: Standard undergraduate topics of electrical circuits and circuit theory, including lumped elements, voltage and current sources, circuit parameters, and maximum power transfer.

• **Optimization, learning and control**

Linear Algebra: Matrix Algebra, Systems of linear equations, Eigenvalues and Eigenvectors, Fundamental Subspaces.

Differential equations: Basic theory of types of differential equations, Complementary solution and Particular Integral, Solution using Laplace transform, Solution of system of linear ODEs

Probability and Statistics: Sampling theorems, Conditional probability, Joint Probability, Random variables, Discrete and continuous distributions, Uniform, Poisson, Normal and Binomial distribution, Evaluating expectations, conditional expectations.

Control: Basic control principles, Transfer functions, Root Locus, Bode Plots, Phase and Gain margins, Knowledge and construction of basic controllers (PD, PI, PID), Basics of state-space analysis, Stability of Linear systems

Optimization: Basics of linear and nonlinear programming, Optimality conditions, Basics of convex analysis

· **Electronics Design & Automation**

Digital Circuits: Boolean Algebra, CMOS inverter, Flip-flops, Combinational and Sequential Circuits.

Circuits & Systems: Circuit analysis techniques, Op-Amp, data path elements, CMOS Circuits, Sequential elements, logic families, memory, FSM, pipeline basics, Digital circuits (FSM/FFs)

· **Nanophotonics and Metamaterials (Computation and Experiments)**

Electromagnetics: Standard undergraduate and postgraduate topics in electromagnetism, Maxwell's equations and Boundary conditions.

Semiconductor Physics: Energy band theory, Carrier statistics, Intrinsic & extrinsic semiconductors, Optical Properties of Semiconductors (Concept of refractive index, Absorption, etc.)

· **Computational Nanoelectronics & Spintronics**

i. Understanding of Basic Electronics.

ii. Basic Quantum Mechanics: quantum confined systems, quantum tunneling, etc.

iii. Crystallography and Band Theory of Solids: crystal structure, energy band structure, effective mass, carrier mobility, etc.

iv. Semiconductor Device Physics: drift-diffusion model of current flow in semiconductor, p-n junctions, MOSFETs, non-ideal behaviour in MOSFETs, Nanoscale MOSFETs, short-channel effects, ballistic transport, etc.

v. Basic Knowledge of Magnetism, etc.
