Department of Electronics Engineering
S. V. National Institute of Technology, Surat-395007

# Syllabus for Ph.D. ENTRANCE TEST (2021-22)

## Section: I Compulsory for all students (25 Marks)

### A. Fundamental of Electronics & General Aptitude

| Topic | Contents |
|---|---|
| A1 | General Aptitude |
| A2 | Engineering Mathematics |
| A3 | Networks, Signals and Systems |
| A4 | Electronic Devices and Circuits |
| A5 | Digital Circuits |
| A6 | Communications |

## Section: II Specialization Specific (25 Marks)

- Student may choose maximum **ANY TWO** from the groups **B, C, D and E**.
- Each group **B, C, D and E** carry ***25 Marks*** weightage.

### B. Communication Systems

| Topic | Contents |
|---|---|
| B1 | Wireless Communication: |
| B2 | RF & Microwave Engineering |
| B3 | Optical Communications |

### C. Microelectronics and VLSI Design

| Topic | Contents |
|---|---|
| C1 | Semiconductor Physics and Device Modeling |
| C2 | Digital Integrated Circuit |
| C3 | Analog VLSI Design |
| C4 | Digital System Design |
| C5 | Physical VLSI design & Automation |

### D. Electronics System Design

| Topic | Contents |
|---|---|
| D1 | Processor Architecture |
| D2 | Embedded Systems |
| D3 | Electronics Instrumentation |
| D4 | VLSI Design |
| D5 | Image and Speech Processing |
| D6 | Machine learning |

### E. Signal Processing & Machine Learning

| Topic | Contents |
|---|---|
| E1 | Probability and Random Processes |
| E2 | Digital Signal Processing |
| E3 | Speech Processing |
| E4 | Image Processing |
| E5 | Neural Networks |
| E5 | Introduction to Machine Learning |
| E7 | Deep Learning |

# Detailed Syllabus

## Section: I Compulsory for all students (25 Marks)

### A. Fundamental of Electronics & General Aptitude (25 Marks)

**A1: General Aptitude**

**Verbal Aptitude Basic English grammar:** Tenses, articles, adjectives, prepositions, conjunctions, verb-noun agreement, and other parts of speech Basic vocabulary: words, idioms, and phrases in context Reading and comprehension Narrative sequencing

**Quantitative Aptitude Data interpretation:** data graphs (bar graphs, pie charts, and other graphs representing data), 2- and 3-dimensional plots, maps, and tables Numerical computation and estimation: ratios, percentages, powers, exponents and logarithms, permutations and combinations, and series Mensuration and geometry Elementary statistics and probability.

**Spatial Aptitude:** Transformation of Shapes such as translation, rotation, scaling, mirroring, assembling, and grouping Paper folding, cutting, and patterns in 2D and 3D dimensions

**A2: Engineering Mathematics:**

**Linear Algebra:** Vector space, basis, linear dependence and independence, matrix algebra, eigenvalues and eigenvectors, rank, solution of linear equations – existence and uniqueness.

**Probability and Statistics:** Mean, median, mode and standard deviation; combinatorial probability, probability distribution functions - binomial, Poisson, exponential and normal; Joint and conditional probability; Correlation and regression analysis.

**A3: Networks, Signals and Systems:**

**Network solution methods:** nodal and mesh analysis; Network theorems: superposition, Thevenin and Norton's, maximum power transfer; Time domain analysis of simple linear circuits; Solution of network equations using Laplace transform; Frequency domain analysis of RLC circuits; Linear 2-port network parameters: driving point and transfer functions; State equations for networks.

**Continuous-time signals:** Fourier series and Fourier transform representations, sampling theorem and applications; Discrete-time signals: discrete-time Fourier transform (DTFT), DFT, FFT, Z-transform, interpolation of discrete-time signals; LTI systems: definition and properties, causality, stability, impulse response, convolution, poles and zeros, parallel and cascade structure, frequency response, group delay, phase delay, digital filter design techniques.

Transient and steady-state analysis of LTI systems; Frequency response; Routh- Hurwitz and Nyquist stability criteria; Bode and root-locus plots; Lag, lead and lag-lead compensation;

State variable model and solution of state equation of LTI systems.

**A4: Electronic Devices and Circuits:**

Energy bands in intrinsic and extrinsic silicon; Carrier transport: diffusion current, drift current, mobility and resistivity; Generation and recombination of carriers; Poisson and continuity equations; P-N junction, Zener diode, BJT, MOS capacitor, MOSFET, LED, photo diode and solar cell; Integrated circuit. Fabrication process: oxidation, diffusion, ion implantation, photolithography and twin-tub CMOS process.

Small signal equivalent circuits of diodes, Simple diode circuits: clipping, clamping and rectifiers; Structure and operation of BJTs and MOSFETs; Single-stage BJT and MOSFET amplifiers: biasing, bias stability, mid-frequency small signal analysis and frequency response; concept of GBW product, BJT and MOSFET amplifiers: multi-stage, differential, feedback, power ,specification of an op-amp: offset voltages and currents, CMRR, slew rate, PSRR, input bias and offset currents, frequency response, GBW product, AC –DC Models of Op-Amp, Applications of Op-amp : Gain Amplifiers, Active filters; Sinusoidal oscillators, criterion for oscillation, Function generators, wave-shaping circuits and 555 timers; Phase lock loop.

**A5: Digital Circuits:**

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| Number systems; Combinatorial circuits: Boolean algebra, minimization of functions using Boolean identities and Karnaugh map, logic gates and their static CMOS implementations, arithmetic circuits, code converters, multiplexers, decoders and PLAs; Sequential circuits: latches and flip-flops, counters, shift-registers and finite state machines; Data converters: sample and hold circuits, ADCs and DACs; Semiconductor memories: ROM, SRAM, DRAM; 8-bit microprocessor (8085): architecture, programming, Memory and I/O interfacing. |
| **A6: Communications:** |
| Random processes: autocorrelation and power spectral density, properties of white noise, filtering of random signals through LTI systems; Analog communications: amplitude modulation and demodulation, angle modulation and demodulation, spectra of AM and FM, super heterodyne receivers, circuits for analog communications; Information theory: entropy, mutual information and channel capacity theorem; Source coding and Channel Coding, Digital communications: PCM, DPCM, digital modulation schemes, amplitude, phase and frequency shift keying (ASK, PSK, FSK), QAM, MAP and ML decoding, matched filter receiver, calculation of bandwidth, SNR and BER for digital modulation; Fundamentals of error correction, Hamming codes; Timing and frequency synchronization, inter-symbol interference and its mitigation; Basics of TDMA,FDMA and CDMA. |

**Section: II Specialization Specific (25 Marks)**

- Student may choose maximum **ANY TWO** from the groups **B, C, D and E**.
- Each Topic in the group carries ***25 Marks*** weightage.

**B. Communication Systems (25 Marks)**

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| **B1: Wireless Communication** |
| Cellular Communication Infrastructure: Cells, Clusters, Cell Splitting, Frequency Reuse Concept, Cellular System Components, Handoff, Fixed and Dynamic Channel Assignments, Cellular Interferences: Co-Channel and Adjacent Channel, Sectorization, Attributes of CDMA in Cellular Systems. Pathloss and shadow fading, Two ray propagation model, Large scale and small scale fading, Multipath propagation, Doppler spread, delay spread, Wireless channel as an LTI system, input-output model of wireless channel, continuous time baseband equivalent model of wireless channel, discrete time baseband equivalent model of wireless channel, AWGN channel, Flat and frequency selective fading channels, slow and fast fading channels, coherence time, coherence bandwidth, Rayleigh and Rician fading channel modelling. |
| **B2: RF & Microwave Engineering** |
| Divergence and Stoke's Theorem, Coulomb's law, Gauss's law and Applications, Electric Potential, Poisson's and Laplace Equations, Biot-Savart's law, Faraday's law and Ampere's Work law in the Differential Vector form , Flux rule for Motional EMF, Magnetic Vector Potential, Introduction to The Equation of Continuity For Time Varying Fields, Inconsistency of Ampere's Law, Maxwell's Equation, Condition at a Boundary Surface, Poynting Theorem, Scattering Parameters- Definition and Meaning of S-parameters, Transmission Line Equations, Voltage and Current Waves, Solutions for Different Terminations, Transmission-line Loading, Impedance Transformation and Matching, Rectangular Waveguides, Antenna Parameters and Definitions. |
| **B3: Optical Communications** |
| Elements of Fiber Optic Communication, Light Transmission Basics, Optical Spectrum, Wavelengths, Frequencies, Channel Spacing, Optical Power, Nature of Light, Basic Optical Laws, Propagation of Light in Fiber, Types of Optical Fiber, Degradation of Signals in Optical Fiber, Attenuation, Absorption, Scattering Losses, Bending Losses, Dispersion. Optical Components: Principle and Operation of Optical Source, Detectors, Amplifiers, Modulators, Couplers, Isolators, Circulators, Fiber Gratings, Filters, Switches. Nonlinear Effects in Fiber: Distortion in Signal Due To Nonlinearities In Fibers, Self-Phase Modulation, Cross Phase Modulation, Stimulated Raman Scattering, Stimulated Brillouin Scattering, Four Wave Mixing, Optical Solitons. |

## C. Microelectronics and VLSI Design (25 Marks)

| C1: Semiconductor Physics and Device Modeling |
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| Fermi energy, density of states function, quantum tunneling, potential inside a semiconductor, semiconductor in Equilibrium, Energy band diagrams, Carrier transport phenomena and models, PN junction, metal semiconductor and hetero junctions. MOSFET - structure, characteristics and operation, MOSFET capacitances, Short and Narrow channel effects, MOS modeling |
| **C2: Digital Integrated Circuit** |
| Introduction to RTL, DTL TTL, Schottky TTL, IIL and ECL logic family, concept of Noise margin, fan out and propagation delay, CMOS inverters - calculation of VTC critical points, power dissipation, rise time and fall time, Fabrication process flow, layout design rules, full-custom mask layout design, stick diagram. |
| **C3: Analog VLSI Design** |
| Current Mirror, Voltage and Current references, Single stage amplifiers, Cascode amplifier, Differential amplifiers, Output amplifiers, CMOS Analog opamps, Single stage and two stage Comparators, Sample and Hold circuits, Nyquist rate ADCs and DACs. |
| **C4: Digital System Design** |
| CMOS Logic Circuits, Combinational and Sequential Logic Circuits, Pass transistor and Transmission gate logic, Dynamic CMOS Logic, Semiconductor Memory Design. Data Path subsystems– Adders, Multipliers, Shifters |
| **C5: Physical VLSI design & Automation** |
| Intro to VLSI CAD & Logic Synthesis, Graph Theory & Optimization problems, Boolean Function Representation & Manipulation: BDDs, Satisfiability & Graph Covering.Optimization Goals in Floor planning, Floor planning Algorithms, Placement Algorithms, Global and local routing, Power and Ground Routing, Static timing analysis. |

## D. Electronics System Design (25 marks)

| D1: Processor Architecture |
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| Processor Design and Concept: Review of Basic Computer Organization, Performance Evaluation Methods, Introduction to RISC Instruction Pipeline, Instruction Pipeline & Performance, Instruction Set Pipeline: Pipeline Hazards, Control Hazards & Branch Prediction, MIPS Pipeline for Multi-Cycle Operations, Pipeline scheduling Techniques, Cache memory principle and optimization |
| **D2: Embedded Systems** |
| ARM processor architectures, registers, current program status register, pipeline, exception, interrupt and vector table, memory map, ARM and thumb mode memory management unit, ARM architecture, ARM architecture revision, cortex processor architecture, overview of C compiler, basic C compiler, C looping structure, register allocation, function calls, pointer aliasing, structure arrangement, bit fields, unaligned data and endianness, division, floating point, inline function and inline assembly, RTOS, PCB Design. |
| **D3: Electronics Instrumentation** |
| Difference amplifiers, instrumentation amplifier, Op-Amp DC Error Analysis, compensated op-amp and non-compensated opamp, summing, scaling and averaging amplifiers, concept of negative resistance, voltage to current converter with floating and grounded load, current to voltage converter, integrator and differentiator, gyrator, frequency dependent negative resistance circuit, first order active filters, second-order active filters, multiple feedback filters (band pass and band reject filters), all pass filter, cascade design |

of filters, magnitude and frequency scaling concept, oscillators, phase shift and Wien bridge oscillators.
Temperature, Pressure and flow measurement techniques, 4-20 mA current loop, locking amplifiers, Isolation Techniques, Hall-effect principle and applications as displacement sensor ,Instrumentation amplifier, Optical and RF sensors, MEMS fabrication, Bio medical sensors, Sensors used in robotics and industrial automation, Concept of PCB Design and housing.

**D4: VLSI Design**

Static and dynamic characteristics of CMOS inverters, delay estimation, logical efforts and transistor sizing, power dissipation, interconnect, combinational CMOS logic circuits, complex logic circuits, behavior of MOS logic elements, SR latch circuit, clocked latch and flip-flop circuits, CMOS D-latch and edge-triggered flip-flop, pass transistor circuits, Stick diagram and Layout, VLSI Design Flow: Full custom and Semi Custom, Verilog/VHDL, FPGA architecture, Verification and Testing.
AC Model of MOS, MOS resistors, current sink/source, current mirrors, differential, cascode and current amplifiers, output amplifiers, high gain amplifier architectures, Noise

**D5: Image and Speech Processing**

**Image Processing:**

Fundamentals of Image Processing; Image Sampling and Quantization, Relationships between Pixels-Nearest Neighbor, Adjacency, Connectivity, Regions, and Boundaries; Distance Measures, Image enhancement in spatial domain and frequency domain, Image Restoration, Image Compression, Image Segmentation, Image Morphology.

**Speech Processing**

Basics of speech production and perception, Short-time processing, Short-term zero crossing rate, Short-term energy, Short-term autocorrelation function, Pitch and Formant estimation, spectrum and cepstrum analysis, Filter-bank analysis, linear prediction (LP) analysis of speech.

**D6: Machine Learning**

Introduction, Machine learning basics, Supervised Learning: Artificial Neural Network, classifying with k-Nearest Neighbour classifier, Support vector machine classifier, Decision Tree classifier, Naive Bayes classifier, Bagging, Boosting, Improving classification with the AdaBoost meta algorithm. Regression, Linear Regression, Multivariate Regression, Logistic regression, Principal Component Regression, Tree-based regression. Bias/variance trade-off, Unsupervised Learning, Reinforcement Learning, Feature extraction - Principal component analysis, Singular value decomposition. Feature selection, feature ranking and subset selection.

## E. Signal Processing (25 Marks)

**E1: Probability and Random Processes**

Probability as Frequency of Occurrence, Set, Sample Space and Events, Axiomatic Definition of Probability, Mutually Exclusive Events, Joint Probability, Conditional Probability and Statistical Independence, Bays Theorem, Continuous and Discrete Random Variables, Cumulative Distribution Function (CDF), Probability Density Function (PDF), Properties of CDF and PDF, Uniform and Gaussian PDFs, Transformations of Random Variables, PDF of Transformed Random Variable, Mean and Variance, Chebyshev's Inequality, Statistics of Stochastic Process, Mean, Autocorrelation, Autocovariance, Stationary Processes: Strict Sense Stationary and Wide Sense Stationary, Power Spectral Density, Joint Statistical Averages of Two Random Processes, Cross Correlation and Cross Covariance.

**E2: Digital Signal Processing**

Review of Discrete Signal representation and Analysis; Time and Frequency domain design techniques for IIR and FIR filters; Adaptive filters; Multirate signal processing

**E3: Speech Processing**

Introduction, Speech Production and Perception, Short-term processing, Time domain analysis: short-time energy, short-time autocorrelation, short-time zero-crossing; Frequency domain analysis, Short-term Fourier transform (STFT); Filter-bank analysis; Spectrogram

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| analysis; Cepstrum analysis. |
| **E4: Image Processing:** |
| Introduction, Image Enhancement in spatial domain and frequency domain, Image Transform, Image Compression, Image Restoration, Image Segmentation, Image Morphology. |
| **E5: Neural Network:** |
| Introduction to neural networks, biological and artificial neurons, perceptron's–classification and linear separability, XOR problem, network architectures, multilayer feedforward networks and recurrent networks, generalized delta rule, multilayer networks, associative memory, convolutional neural networks, fuzzy systems and neuro fuzzy systems, application of neural networks. |
| **E6: Introduction to Machine Learning:** |
| Introduction: Statistical Decision Theory - Regression, Classification, Bias Variance, Linear Regression, Multivariate Regression, Subset Selection, Shrinkage Methods, Principal Component, Regression, Partial Least squares, Linear Classification, Logistic Regression, Linear Discriminant Analysis, Support Vector Machines, Parameter Estimation - MLE, MAP, Bayesian Estimation, Gaussian Mixture Models, Expectation Maximization. |
| **E7: Deep Learning:** |
| Introduction, Deep Networks: Deep Feedforward Networks - Learning XOR - Gradient Based learning - Hidden Units - Back-propagation and other Differential Algorithms - Regularization for Deep Learning - Optimization for training Deep Models. Foundations of Convolutional Neural Network, Deep Convolutional Models, Recurrent Neural Networks. |

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