DEPARTMENT OF ELECTRICAL AND COMPUTER SCIENCE ENGINEERING

Syllabus for Written Test for PhD Admissions

Candidate shall attempt any ONE SECTION of choice.

Section A – Computer Science

- **Basic Mathematics**: linear algebra: vector and matrix properties and operations, solving systems of linear equations; probability and statistics, random variables, random processes
- **Basic Programming Concepts**: Iterative programming (for and while loop constructs), conditional executions, functions, pointers, recursions, File handling, procedural and object oriented programming concepts
- **Data Structures**: Linear data structures: arrays, stack, queue, linked lists; non-linear data structures: binary search tree, balanced binary search tree, heap tree, graphs; representation of data structures in computer memory; applications and complexity of operations on / using data structures
- **Design and Analysis of Algorithms:** Asymptotic notations, sorting and search- insertion sort, selection sort, merge sort, quicksort, binary search, design techniques: divide and conquer, greedy, dynamic programming, data structures: heaps, union of disjoint sets, search trees, algorithms on graphs: exploration, connectivity, shortest paths, directed acyclic graphs, spanning trees, Intractability: NP completeness, reductions
- **Computer networks:** TCP/IP protocol stack and design of Internet, application layer: HTTP, FTP, DNS, P2P file sharing, transport layer: Issues related to process-to process communication and reliable data transfer, TCP and UDP operations; network layer: routing, addressing, QoS issues, IPv4 and IPv6 protocols; data link layer: wired and wireless local area networks and protocols
- **Digital Logic Design:** Boolean algebra, logic gates, design of combinational logic circuits - adder, subtractor, multiplier, comparator; sequential logic circuits - flip-flops, registers, counters
- **Computer Organization:** Machine instructions and addressing modes. ALU, data-path and control unit. Instruction pipelining, pipeline hazards. Memory hierarchy: cache, main memory and secondary storage; I/O interface (interrupt and DMA mode)
- **Theory of Computation:** Regular expressions and finite automata. Context-free grammars and push-down automata. Regular and context-free languages, pumping lemma. Turing machines and undecidability
- **Compiler Design:** Lexical analysis, parsing, syntax-directed translation. Runtime environments. Intermediate code generation. Local optimisation, Data flow analyses: constant propagation, liveness analysis, common subexpression elimination
- **Databases:** ER-model. Relational model: relational algebra, tuple calculus, SQL. Integrity constraints, normal forms. File organization, indexing (e.g., B and B+ trees). Transactions and concurrency control
- **Operating Systems:** Interprocess communication, deadlock, memory management, file system design, device/IO management

Section B – Signals and Image Processing

- **Engineering Mathematics:**
  - **Linear Algebra**: Vector space, basis, linear dependence and independence, matrix algebra, eigenvalues and eigenvectors, rank, solution of linear equations- existence and uniqueness.
  - **Calculus:** Mean value theorems, theorems of integral calculus, evaluation of definite and improper integrals, partial derivatives, maxima and minima, multiple integrals, line, surface and volume integrals, Taylor series.
  - **Differential Equations**: First order equations (linear and nonlinear), higher order linear differential equations, Cauchy's and Euler's equations, methods of solution using variation of parameters, complementary function and particular integral, partial differential equations, variable separable method, initial and boundary value problems.
  - **Vector Analysis**: Vectors in plane and space, vector operations, gradient, divergence and curl, Gauss's, Green's and Stokes' theorems.
  - **Complex Analysis**: Analytic functions, Cauchy's integral theorem, Cauchy's integral formula, sequences, series, convergence tests, Taylor and Laurent series, residue theorem.
  - **Probability and Statistics**: Mean, median, mode, standard deviation, combinatorial probability, probability distributions, binomial distribution, Poisson distribution, exponential distribution, normal distribution, joint and conditional probability
- **Networks, Signals and Systems:**
  - **Circuit analysis**: Node and mesh analysis, superposition, Thevenin's theorem, Norton's theorem, reciprocity. Sinusoidal steady state analysis: phasors, complex power, maximum power transfer. Time

andfrequency domain analysis of linear circuits: RL, RC and RLC circuits, solution of network equations usingLaplace transform.
    - Linear 2-port network parameters, wye-delta transformation.
    - **Continuous-time Signals**: Fourier series and Fourier transform, sampling theorem and applications.
    - **Discrete-time Signals**: DTFT, DFT, z-transform, discrete-time processing of continuous-time signals. LTIsystems: definition and properties, causality, stability, impulse response, convolution, poles and zeroes, frequency response, group delay, phase delay
- **Electronic Devices:**
    - Energy bands in intrinsic and extrinsic semiconductors, equilibrium carrier concentration, direct and indirect band-gap semiconductors.
    - **Carrier Transport**: diffusion current, drift current, mobility and resistivity, generation and recombinationof carriers, Poisson and continuity equations.
    - P-N junction, Zener diode, BJT, MOS capacitor, MOSFET, LED, photo diode and solar cell
- **Analog Circuits:**
    - **Diode circuits**: clipping, clamping and rectifiers.
    - **BJT and MOSFET amplifiers**: biasing, ac coupling, small signal analysis, frequency response. Current mirrors and differential amplifiers.
    - **Op-amp circuits**: Amplifiers, summers, differentiators, integrators, active filters, Schmitt triggers and oscillators
- **Digital Circuits:**
    - **Number representations**: binary, integer and floating-point- numbers. Combinatorial circuits: Boolean algebra, minimization of functions using Boolean identities and Karnaugh map, logic gates and their staticCMOS implementations, arithmetic circuits, code converters, multiplexers, decoders.
    - **Sequential circuits**: latches and flip-flops, counters, shift-registers, finite state machines, propagation delay, setup and hold time, critical path delay.
    - **Data converters**: sample and hold circuits, ADCs and DACs.
    - **Semiconductor memories**: ROM, SRAM, DRAM.
    - **Computer organization**: Machine instructions and addressing modes, ALU, data-path and control unit, instruction pipelining

Section C – Signals, Systems and Processing

- Signal Classification, continuous & discrete time signals, basic operations on signals, classification of systems, linear time invariant (LTI) systems, properties of LTI systems, impulse response, convolution, causality, stability, Fourier Analysis, Fourier Series for periodic signals, Properties of Fourier Series, Gibbs Phenomenon, Fourier transform, properties of Fourier transform, Laplace transform, properties of Laplace transform.
- z-transform, properties of z-transform, Discrete time Fourier transform (DTFT), properties of DTFT, Discrete Fourier transform DFT, FFT, sampling, sampling theorem, Design of FIR and IIR filters: Bilinear Transformation and windowing methods of filter design.

Section D – Control Systems

- **Engineering Mathematics:**
    - **Linear Algebra**: Vector space, basis, linear dependence and independence, matrix algebra, eigenvalues and eigenvectors, rank, solution of linear equations- existence and uniqueness.
    - **Calculus:** Mean value theorems, theorems of integral calculus, evaluation of definite and improper integrals, partial derivatives, maxima and minima, multiple integrals, line, surface and volume integrals, Taylor series.
    - **Differential Equations**: First order equations (linear and nonlinear), higher order linear differential equations, Cauchy's and Euler's equations, methods of solution using variation of parameters, complementary function and particular integral, partial differential equations, variable separable method, initial and boundary value problems.
    - **Vector Analysis**: Vectors in plane and space, vector operations, gradient, divergence and curl, Gauss's, Green's and Stokes' theorems.
    - **Complex Analysis**: Analytic functions, Cauchy's integral theorem, Cauchy's integral formula, sequences, series, convergence tests, Taylor and Laurent series, residue theorem.
    - **Probability and Statistics**: Mean, median, mode, standard deviation, combinatorial probability, probability distributions, binomial distribution, Poisson distribution, exponential distribution, normal distribution, joint and conditional probability

- **Control Systems:** Basic control system components; Feedback principle; Transfer function; Block diagram representation; Signal flow graph; 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.

Section E – Power Systems, Machines & Power Electronics

- **Power Systems:** Generation, voltage and frequency control, ac and dc transmission, performance of overhead transmission lines and underground cables, transmission line compensation, distribution systems, per-unit quantities, load dispatch, power factor correction, symmetrical components, fault analysis, protection.
- **Electrical Machines:** Operation and performance of Single- and three-phase two winding transformers and auto-transformers; principle of electromechanical energy conversion; dc machines: operation, characteristics, speed control; Three-phase induction machines: operation, performance, characteristics, speed control; Operating principle of single-phase induction motors; Synchronous machines: Operation, performance and characteristics.
- **Power Electronics:** power semiconductor devices operation and characteristics; operation-control-applications of dc-dc, ac-dc, and dc-ac converters.

Section F – Communication Systems

- Amplitude modulation and demodulation, angle modulation and demodulation, Random variables and random process, autocorrelation and power spectral density, properties of white noise, filtering of random signals through LTI systems. PCM, DPCM, digital modulation schemes (ASK, PSK, FSK), matched filter receiver. Fundamentals of error probability in digital communication systems.

Section G – Drones and Communications

- **Drones:** Basics of Drones, Assembly, Calibrations and Different types of sensors, Regulations.
- **Analog communications:** amplitude modulation and demodulation, angle modulation and demodulation, spectra of AM and FM, super heterodyne receivers.
- **Information theory:** entropy, mutual information and channel capacity theorem.
- **Digital communications:** PCM, DPCM, digital modulation schemes (ASK, PSK, FSK, QAM), bandwidth, inter-symbol interference, MAP, ML detection, matched filter receiver, SNR and BER. Fundamentals of error.

Section H – Electronics

- **Electronic Devices:** Energy bands in intrinsic and extrinsic semiconductors, equilibrium carrier concentration, direct and indirect band-gap semiconductors; Carrier Transport: diffusion current, drift current, mobility and resistivity, generation and recombinationof carriers, Poisson and continuity equations; P-N junction, Zener diode, BJT, MOS capacitor, MOSFET, LED, photo diode and solar cell
- **Analog Circuits:** Diode circuits: clipping, clamping and rectifiers; BJT and MOSFET amplifiers: biasing, ac coupling, small signal analysis, frequency response. Current mirrors and differential amplifiers; Op-amp circuits: Amplifiers, summers, differentiators, integrators, active filters, Schmitt triggers and oscillators.