SYLLABUS

FOR THE

DOCTORAL QUALIFYING EXAM

Ph.D/D.Eng. Computer Engineering Option

These are the general topics for the appropriate subjects in the Qualifying Exam. If you have specific questions, it will be best to contact the appropriate Instructor if you have any questions.

August 2013
CpE GROUP 1: CIRCUITS AND DEVICES

**CIRCUITS AND NETWORKS**
- Basic Circuit Laws: Ohm's Law, Kirchhoff's Laws
- Thevenin's and Norton's theorems
- Mesh and nodal analysis
- Superposition theorems
- Maximum power transfer theorems
- Driving-point impedances
- Dependent sources
- Natural and forced responses
- Phasors and sinusoidal steady state response
- Series resonance and parallel resonance
- Two-port network parameters
- Linear op amp circuits

**ELECTRONIC DEVICES**
- Diodes
- Field Effect Transistors
- Dipolar Junction Transistors
- Single stage Amplifiers including large signal and small signal analysis
- Frequency response of single stage Amplifiers using hybrid-Π model

**ELECTRONIC CIRCUITS**
- Design and Application of Operational Amplifiers
- Current Sources and Current Mirrors
- Differential Pair Amplifiers
- Multistage Amplifier Circuits
- Frequency Response
- Feedback Amplifiers
- ADC/DAC

**SIGNALS AND SYSTEMS**
- Mean, mean square, and RMS values
- DC, AC, and complex power in deterministic signals
- Phasors
- Fourier series and finite Fourier series
- Fourier transform and discrete Fourier transform
- The s-plane
- Laplace transform
CpE GROUP 2: Computer Hardware

- **LOGIC DESIGN**
  - Boolean algebra
  - Boolean functions-standard forms and simplification including Karnaugh maps
  - Analysis of combinational circuits
  - Synthesis of combinational circuits - two-level circuits, multi-level circuits, and minimal realizations with
  - various types of gates and certain modular circuits
  - Modular combinational circuits: Decoders, encoders, multiplexers, and demultiplexers
  - Latches and flip-flops
  - Analysis of synchronous sequential circuits (finite state machines) – Moore model and Mealy model
  - Synthesis of synchronous sequential circuits (finite state machines) – Moore model and Mealy model

- **Advanced Digital Systems Design**
  - Memory System Units.
  - PLA, PAL and PLD designs.
  - Floating point representation, error detection codes.
  - Register transfer design and implementation, Register Transfer Language (RTL).
  - Micro-operations and their hardware implementations.
  - Timing and control, memory reference instructions.
  - ALU and assembly programming of arithmetic and logic operations.
  - Data-path Design
  - Microprogramming control, design of control unit.
  - CPU design.
  - Pipelining and pipelined Design.
  - FPGA implementation using VHDL or Verilog Hardware Description Languages
CpE GROUP 3: Computer Software

- **Data Structures and Algorithms**

  - **Application Programming**
    - ✓ Basic C++
    - ✓ Abstract Data Types
    - ✓ C++ Classes: Constructors, accessors, mutators
    - ✓ C++ Classes: Operator overloading
    - ✓ Linked Lists, pointers, dynamic memory allocation
    - ✓ Destructors, copy constructor, and overloaded assignment for classes with pointer members
    - ✓ Stacks and Depth First Search (Maze traversal)
    - ✓ Queues and Breadth First Search (Shortest path)
    - ✓ Complexity and Big O
    - ✓ Recursion
    - ✓ Class Templates
    - ✓ Binary Search Trees
    - ✓ Simple (O(n)) Sorting Algorithms
    - ✓ Heaps, Heap operations, and Heap Sort
    - ✓ Quicksort, Radix Sort, and Merge Sort
    - ✓ Hash Tables
    - ✓ C++ Exceptions
    - ✓ Inheritance
    - ✓ Dynamic Arrays

- **Application Programming**

  - ✓ Basic C concepts: constants, variables, operators, expressions and assignment statements
  - ✓ Console input and output (scanf() and printf())
  - ✓ Decisions and selection: if and switch statements
  - ✓ Repetition: while, do-while, and for loops
  - ✓ Functions: calling functions and writing function prototypes/definitions
  - ✓ One and two-dimensional arrays
  - ✓ Character strings
  - ✓ C-style structures
  - ✓ File input / output

CpE GROUP 4: Computer Systems

- **Network Design**
✓ Foundation and building blocks of a network (hardware and software); internal organization of the network, a system approach
✓ Network Architectures; packet switching; Direct Link Networks Layering and Protocols
✓ Implementing Network Applications interfaces (Sockets), Routing Algorithms
✓ TCP/IP (Ipv6) and UDP; reliable and unreliable stream connection; sliding window concept for TCP; Connection establishment and termination; adaptive retransmission
✓ Congestion control algorithms; internetworking and resource allocation.
✓ Internet, Intranet, Ethernet, star architecture, FDDI architecture, subnet issues, ARP, RARP, BOOTP, DHCP.
✓ ATM architectures, AAL networks; TCP over ATM; voice over IP (introduction)
✓ Internetworking; Internet Multicasting; autonomous systems; EGP, BGP, OSPF and IGMP protocols.
✓ Mobile Computing; Private Network Interconnection; foreign agent discovery;
✓ Client-Server model design; 2-tiers and n-tier design
✓ Introduction to Internet security and Firewall design; send-box design; static and run-time security;
✓ Multi-media applications, DNS, HTTP, SNTP, LDAP, SMTP, MIME, RTP, Data compression; XDR, ASN-1, NDR; Lossless compression algorithms; Image, Video, and Audio compression and transmission over a network.

• Operating Systems:

✓ Computer-System Structures, Operating-System Structures
✓ Processes, Threads
✓ CPU Scheduling
✓ Process Synchronization
✓ Deadlocks
✓ Memory management, Virtual Memory
✓ File Systems
✓ I/O Systems, Mass-Storage Structure
✓ Operating System Network Structure and Distributed Communication
✓ Distributed Coordination
✓ Distributed File Systems
✓ Protection and Security

• COMPUTER ARCHITECTURE – Please speak to Instructor

• ASSEMBLY LANGUAGE AND MICROPROCESSORS

✓ Two's complement arithmetics
✓ Addressing modes and address generation
✓ Data organization (endianness and alignment)
✓ Stacks
✓ Basic instructions (data transfer, arithmetic, logic, shift, rotation)
✓ Conditional and unconditional branches
✓ Subroutines
✓ Protected-mode memory management (address translation, multitasking and protection)
✓ Hardware organization of memory address space
✓ Memory interface circuitry and subsystem design
✓ Input and output interfacing

• MICROPROCESSORS 2 AND EMBEDDED SYSTEMS
  ✓ Embedded Processor Architectures and Programming
  ✓ Primary and Secondary Storages
  ✓ Memory System Organization, Decoding, and Timing.
  ✓ Communication Protocols and Interfaces (e.g. serial, parallel, \text{I}^2\text{C}, \text{PCI}, etc.)
  ✓ Interrupt and Direct Memory Access
  ✓ Data acquisition and processing (e.g. ADC)
  ✓ Interaction of Hardware and Software and Device Driver
  ✓ Parallel/Multithreaded Programming
CpE GROUP 5: MATHEMATICS

• VECTOR CALCULUS AND DIFFERENTIAL EQUATIONS
  ✓ Vector algebra
  ✓ Orthogonal Coordinate System
  ✓ Curl, divergence and gradient operations
  ✓ Integrals of scalar and vector fields
  ✓ Stoke's theorem
  ✓ Divergence Theorem
  ✓ Solution of linear homogeneous differential equations
  ✓ Complementary function and particular integral
  ✓ Series solution of D.E. and Forbenius method
  ✓ Bessel's and Legendre's differential equations
  ✓ Hermite and Laguerre polynomials
  ✓ Dirichlet's and Neumann's problems
  ✓ Separation of variables method of solving partial D.E.

• Complex Variables and Linear Algebra
  ✓ Complex algebra, Argand plane, integer and fractional powers, set theory, functions, limits and continuity, analyticity, harmonic functions, basic transcendental functions.
  ✓ Integration in the complex plane, contour integration, path independence, Cauchy-Goursat Theorem, Cauchy Integral formula
  ✓ Infinite series, power, Taylor and Laurent series
  ✓ Classification of singularities, evaluation of residues, evaluation of real integrals with residue calculus, evaluation of
  ✓ Fourier Transform type integrals with residues, inversion of Laplace transforms with residues

  o Linear Algebra:
    ✓ Elementary algebraic operations, properties of determinants, inversion of a matrix, orthogonal matrices
    ✓ Simultaneous equations: Gaussian elimination, Cramer's rule, linear dependence of vectors
    ✓ Eigenvalues, eigenvectors, modal matrix, spectral matrix, diagonalization of a matrix

• Discrete Mathematics and Structures
  ✓ Binary and other bases, Floating-Point representations, error detection and correction.
  ✓ Logic, truth tables, and digital abstraction with applications to digital circuits.
  ✓ Set Theory: Venn diagrams, and set operations with applications to computers
  ✓ Relations and Functions.
  ✓ Mathematical reasoning, proof by induction, recursive algorithms.
  ✓ Algorithms and their complexity: Design of efficient algorithms with applications to computer and electrical and computer engineering fields.
✓ Solving recurrence relations, divide-and-conquer relations.
✓ Permutations, combinations and counting techniques.
✓ Application of probability and statistics to performance measures, cost-performance trade-offs and options with applications to CPUs, memory, I/O, systems and networking.
✓ Introduction to graphs and graph algorithms, connectivity, shortest path algorithms with applications to networking and distributed systems.
✓ Introduction to trees, tree traversal algorithms and applications to the computer and electrical computer engineering fields.

• **Probability and Random Signals**
  ✓ Issues of the nature and characterization of random events, with particular reference to noise and its effect on systems
  ✓ Discrete and continuous probability
  ✓ Random processes and the response of linear systems to random processes including noise processes
  ✓ Applications of theory to reliability and spectral analysis, confidence intervals and confidence limits.