

Professional PhD Degree Program in Computer Science

Qualifying Examination (QE)

Course Textbook and Topics for the QE

Last updated on 5/9/2022

1) CDA 4102 Computer Architecture

Textbook: Computer Systems: A Programmer's Perspective, 3/E (CS:APP3e) by Randal E. Bryant and David R. O'Hallaron.

QE Topics:

- Intro to computer architecture
- Fundamental of computer design
- Instruction set architecture ISA, RISC system
- Pipelining Concept
- Branch Predictions and exceptions
- Instruction level parallelization
- Memory SRAM, DMA, and memory management
- Cache concept, policies, levels, and performance
- Multicore processor design, message passing, shared memory and consistency
- Multithreading, fine grained, coarse grained, and SMT

2) COP 3530 Data Structures and Algorithm Analysis

Textbooks:

Grokking Algorithms, by Aditya Y. Bhargava -- Manning 2016 ISBN 9781617292231.

Open Data Structures: an introduction, by Pat Morin: <https://opendatastructures.org> (FREE). Select the "C++ edition".

Note: students must use C++ when answering the QE question for COP3530.

QE Topics:

- Fundamental Data Structures and Algorithms

- Linked lists
- Stacks
- Queues
- Sets
- Graphs
- Trees
- Hash Tables
- Algorithmic Strategies
 - Algorithm efficiency: growth rates and big-O notation
 - Searching: comparison of various algorithms
 - Sorting: comparison of various algorithms

3) COP 3410 Data Structures and Algorithm Analysis with Python

Textbook: Michael T. Goodrich, Data Structures and Algorithms in Python, Wiley, ISBN: 9781118290279, 1118290275.

Note: students must use Python when answering the QE question for COP3410.

QE Topics:

- Algorithm Analysis
- Recursion
- Array-Based Sequences
- Stacks, Queues
- Linked Lists and Trees
- Maps, Hash Tables, and Skip Lists
- Search Trees
- Sorting and Selection
- Graphs

4) COP 3540 Introduction to Database Structures

Textbook: Database Management Systems, 3rd edition. Raghu Ramakrishnan and Johannes Gehrke. McGraw-Hill, 2002, ISBN-13: 978-0072465631.

QE Topics:

- Conceptual Database Model

- Entity-Relationship (ER) Models
- Logical Database Model
 - SQL
 - Relational Algebra
 - Normalization
- Physical Database Model
 - Storage and Access methods (e.g., Disks, buffers)
 - Indexes (B+tree and Linear Hashing)
 - Query Optimization
 - Transaction Management / Concurrency and Recovery.

5) COP 4610 Computer Operating Systems

Textbook: Operating Systems: Three Easy Pieces, Remzi H. Arpaci-Dusseau and Andrea C. Arpaci-Dusseau. FREE, available at <https://pages.cs.wisc.edu/~remzi/OSTEP/>.

QE Topics:

- Overview of Operating Systems: Functions and Characteristics
- Operating System Principles
- Concurrency
 - Process management -processes and threads
 - Deadlocks and their prevention
- Scheduling and Dispatch
 - Resource allocation and scheduling
 - Process collaboration and synchronization
- Memory Management
 - Memory organization and management
 - Virtual memory organization
 - Virtual memory management
- Virtual machines

6) COT 4400 Design and Analysis of Algorithms

Textbook: Introduction to Algorithms (4th Edition), by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein.

QE Topics:

- Foundations: asymptotic notations, common functions, summations, and recurrences (Master Theorem)
- Sorting: Insertion sort, Merge sort, Heapsort, Quicksort, Sorting in Linear Time
- Medians, minimum and maximum, selection problem
- Divide-and-Conquer
- Basic Data Structures, Binary Search Trees, Hash Tables, Heaps and Priority queues
- Dynamic Programming. Application problems such as Matrix-Chain Multiplication, Longest Common Subsequence
- Greedy Algorithms. Application problems such as Activity-Selection Problem, Huffman Codes
- Elementary Graph Algorithms: graph representation, breadth-first search, depth-first search
- Minimum Spanning Trees: Prim, Kruskal
- Single-Source Shortest Paths: Bellman-Ford, Dijkstra

7) COT 4420 Theory of Computation

Textbook: Peter Linz "An Introduction to Formal Languages and Automata", Sixth Edition, Jones and Bartlett, 2016, ISBN-13: 9781284077247.

QE Topics:

- Deterministic and Non-deterministic Finite Accepters/Automata
- Regular Languages, Regular Expressions and Regular Grammars
- Linear Languages
- Context-Free Languages and Pushdown Automata
- Simplifications of Context-Free Grammars and Normal Forms; three Pumping Lemmas
- Closure Properties of Languages
- Turing Machines
- Hierarchy of Formal Languages and Automata
- The Church-Turing Thesis
- P-NP Classes