King Fahd University of Petroleum & Minerals
College of Computer Science and Engineering
Information and Computer Science Department

Ph.D. in Computer Science

Comprehensive Exam Preparation Guideline

September 24, 2020
Version 1.4

CS Ph.D. Comprehensive Exam Preparation Guideline

The purpose of the Ph.D. comprehensive examination is to ensure that the student advancing to candidacy for the PhD degree has sufficient breadth and depth of knowledge in his field of specialization.

The following is a set of necessary remarks to assist while preparing the exam by examiners and for the exam by students:

1. The Ph.D. comprehensive exam is required for all Ph.D. students.
2. The Ph.D. written comprehensive exam shall be offered twice a year; once in the Fall and another in the Spring semesters.
3. The exam will be held during the 3rd week of the respective semester.
4. The student MUST register Seminar ICS 699 in the same semester of the comprehensive exam. The student will get NP in ICS 699 if he (a) passes the exam (b) attends the department seminars in that term. Failing to do either results in IC.
5. The exam duration is 180 minutes for each area.
6. The exam is closed book.
7. The exam is topic based; it is neither course based, nor book based.
8. The exam tests for fundamental knowledge and academic maturity in the concerned area.
9. The exam contains three types of question:
    a. Questions that test basic foundations in the concerned area (a good undergraduate student should be able to answer these questions)
    b. Questions that test advanced concepts in the concerned area (a good graduate student should be able to answer these questions)
    c. One or more research-oriented questions to assess the student's approach in addressing research problems.
10. The comprehensive examination is graded as either pass or fail. A student must pass the examination in a maximum of two (2) attempts
11. The first attempt of the comprehensive exam must be in the 3rd semester.
12. The second and last attempt of the comprehensive exam must be in 4th semester.
13. If the student declined to take the exam in the 3rd semester and took it for the first time in his 4th semester, he loses his right for a re-take (in case of failure).
14. In the case of failure in the second attempt, the student will be dismissed from the program.
15. The passing grade for each area of the comprehensive exam is 60%.
16. The student is considered pass if he scores below 60% and above 50% and his grade is "A" or above in the specific course in which he showed weakness in the comprehensive exam.
17. For border cases, the committee may arrange for an oral exam to help them make a fair judgment.
18. The exam topics are shown in the following pages.

Area A: "Algorithms and Artificial Intelligence"

Algorithms Topics:

1. Complexity Analysis: Asymptotic complexity, Big O/Ω/Θ, and small-o notations, analyzing iterative and recursive algorithms, the Master theorem.
2. NP-Completeness: Classes P, NP, NP-Complete, and co-NP, polynomial time reductions.
3. Lower bounds: The decision tree and algebraic decision tree methods, the linear time reduction method. (e.g. proving lower bounds for sorting, uniqueness, convex-hull, closest-pair, and the Euclidean minimum spanning tree problems).
4. Backtracking and branch-and-bound techniques. (e.g. Graph-coloring, 8-queens problem, Traveling salesman problem).
5. Approximation algorithms: difference bound, approximation ratio. (e.g. Bin packing, Euclidean traveling salesman, and Vertex cover problems)
6. Randomized algorithms: Monte Carlo and Las Vegas Algorithms, Randomized Quicksort, the Birthday problem.
7. Network flow: Ford-Fulkerson method, maximum capacity augmentation, and shortest path augmentation.
8. Matching: the network-flow method, and the Hungarian tree method.
9. Computational Geometry: Computing the maximal points, the convex-hull problem.

Artificial Intelligence Topics:

1. Uninformed Search
2. Informed Search
3. Constraint Satisfaction Problems (CSPs)
4. Adversarial search, Game Trees and Expectimax
5. Markov Decision Processes (MDPs)
6. Reinforcement Learning
7. Markov Models and Hidden Markov Models (HMMs)
8. Probabilistic models: Bayes' Nets
9. Machine Learning: Regression, Classification, and Clustering
10. Propositional Logic and First-order Logic

Recommended References:

1. M. Alsuwaiyel, "Introduction to Algorithms: Design Techniques and Analysis", World Scientific Publishing Co., Inc. 1999.
2. T. Cormen, C. Leiserson, R. Rivest & C. Stein, "Introduction to Algorithms", 2nd Edition, The MIT Press, 2001.
3. S. Russell and P. Norvig. Artificial Intelligence: A Modern Approach, 3rd Edition (International Edition), Pearson Education, 2009.

Area B: “Systems and Languages”

Operating Systems Topics:

1. Process Concept and Management
2. Multithreading Models
3. Concurrent execution and Bottleneck Analysis
4. Synchronization and Communication of Processes
5. Main and Virtual Memory Management
6. I/O Management, Mass-Storage
7. File System, Error Detection and Recovery
8. Multiprocessor and Real-Time Scheduling
9. Distributed Operating Systems
10. Distributed Deadlock Handling, Distributed Shared Memory, and Distributed File System
11. Performance Analysis and Evaluation of CPU and Disk Scheduling Algorithms
12. Developing Simulation Models for Computer Systems Resources, i.e. CPU, Memory and Disks

Programming Languages Topics:

1. Programming Languages Evaluation Criteria.
2. Describing Syntax and Semantics.
3. Lexical and Syntax Analysis.
4. Subprograms: Referencing, Overloading, Parameter-passing.
5. Imperative Programming Paradigm.
6. Functional Programming Paradigm.
7. Logic Programming Paradigm.

Recommended References:

1. Siblerschatz and Galvin, Operating System Concepts, Ninth Edition, 2014, Wiley.
2. Distributed Operating Systems, Tanenbaum Andrew, http://www.e-reading.me/book.php?book=143358
3. Concepts of Programming Languages, R. Sebesta, 10th Edition, Addison Wesley.

Area C: “Security and Net-centric Computing”

Security and Net-centric Computing Topics:

1. Fundamentals of Computer Networks and the Internet
2. Network Applications: Architectures, Protocols and Systems
3. Transport Layer: Congestion and Flow Control, Protocols
4. Network Layer: Addressing, Routing Algorithms, Protocols
5. Data Link Layer: Framing, Error Control, Medium Access Control, LANs
6. Computer and Network Security: Basics, Malicious Software, Intrusions, Firewalls, VPNs, Network Layer Security Protocols
7. Cryptography: Symmetric and asymmetric ciphers
8. Message Integrity and Digital Signatures
9. Entity Authentication and Key Management
10. Web Application Security
11. Physical Security

Recommended References:

1. Computer Networking: A Top-Down Approach, 6/e, J. Kurose & Keith Ross, Addison Wesley, 2013. http://www.pearsonhighered.com/kurose-ross/
2. B. A. Forouzan, Cryptography and Network Security, McGraw Hill 2007. http://highered.mheducation.com/sites/0072870222/index.html

Area D: “Software Engineering”

Software Engineering Topics:

1. Software Development Processes
2. Software Requirements Engineering
3. Software Architecture
4. Software Design Strategies and Methods
5. Software Quality Analysis and Evaluation
6. Software Maintenance
7. Software Modeling
8. Testing Process and Techniques
9. Quality Assurance
10. Software Project Management

Recommended References:

1. “Software Engineering”, Ian Sommerville, Addison-Wesley; 10th edition, 2015, ISBN-10: 0133943038
2. “Software Engineering: A Practitioner's Approach”, Roger S Pressman and Bruce R. Maxim, 9th edition, 2019, ISBN-10: 126042331X