

Topics for the Qualifying Examination

The qualifying exam for the doctoral program for D.Sc (IT) consists of six areas of study.

1. Data Structures and Algorithms
2. Operating Systems
3. Computer Networks
4. Software Engineering
5. Database Systems
6. Project Management

The above areas are covered in the following topics, which can be used as a guide for Preparing for the exam. You must pass at least 4 out of 6 areas to pass the qualifying exam.

(1) Data Structures and Algorithms

General Information:

- The topics below are covered at different level of details in the following courses offered by our department: COSC 336, COSC 483, COSC 600.
- These topics are standard and are covered in many textbook on algorithms and data structures. We recommend the following textbooks:
 - (W) *Data Structures and Algorithm Analysis (C++ or Java editions)*, by Mark A. Weiss, Addison-Wesley Publishing Co.
 - (CLRS) *Introduction to Algorithms* by Cormen, Leiserson, Rivest, Stein, published by MIT Press and McGraw-Hill.

Topics:

- 1 Basics of Algorithm Analysis:
 - Asymptotic notation (Big-O, little-O, Big-Omega, basic manipulation rules) – W (Chapt. 2), CLRS (Chapt 3)
 - Analysis of recursive algorithms, Master Theorem – CLRS (Chapt 4)
- 2 Linear Data Structures: Lists, Stacks, Queues - W (Chapter 3), CLRS (Chapter 10)
 - Abstract data type characterization
 - Implementations (array, linked lists, doubly linked lists, circularly linked lists)
- 3 Trees
 - Binary trees, Binary search trees (W – Chapter 4)
 - AVL trees (W – Chapter 4)
 - Red-black trees (CLRS – Chapter 13)

- Splay Trees (W – Chapter 4, Section 4.5)
 - B-trees (W – Chapter 4, Section 4.7)
- 4 Hashing (W – Chapter 5)
 - hash functions, open addressing hashing
 - extendible hashing
 - 5 Heaps and Priority Queues
 - binary heaps (W – Chapter 6)
 - leftist heaps (W – Chapter 6, Section 6.6)
 - binomial heaps (W Section 11.2, CLRS – Chapter 19)
 - 6 Sorting Algorithms:
 - insertion sort, select sort, bubble sort (W – Chapter 7)
 - heapsort (W – Section 7.5, CLRS – Chapt. 6)
 - mergesort (W – Section 7.6, CLRS – Section 2.3.1)
 - quicksort (W – Section 7.7, CLRS – Chapt. 7)
 - bucket sort, radix sort (CLRS – Chapter 8)
 - external sorting (W – Section 7.11)
 - 7 Graph Algorithms:
 - data structures for representing graphs (adjacency matrix, adjacency list) (W – Section 9.1.1, CLRS – Section 22.1)
 - Breadth first search (W- Chapter. 9, CLRS – Section 22.2)
 - Depth-first search (W – Section 9.6, CLRS – Section 22.3)
 - Topological sorting (W – Section 9.2, CLRS - Section 22.4)
 - Shortest-path algorithms (Dijkstra, Floyd-Warshall) (W – Section 9.4, CLRS – Chapt 24)
 - Minimum spanning tree algorithms (Kruskal, Prim) (W – Section 9.5, CLRS – Chapt. 23)
 - Network flows ; maximum-flow algorithm (W – Section 9.4.1)
 - 8 General techniques in the design of algorithms (W – Chapter 10, CLRS – Chapters 15 and 16)
 - Divide-and-conquer
 - Dynamic programming
 - Greedy strategies
 - Backtracking
 - Branch-and-bound
 9. Basic notions of computational complexity (W – Section 9.7, CLRS – Chapter 34)
 - lower bounds for sorting
 - reductions among problems
 - NP and NP-complete problems

(2) Operating Systems

General Information:

- Most of the topics below are covered in an introductory graduate course on operating systems, COSC519 offered at Towson University.
 - The following text book or equivalent should be studied for the given topics.
Operating System Concepts, Eight Edition, Silberschatz, Galvin, and Gagne, Wiley Publications.

Topics:

1. Fundamentals (Chapter 1, 2, 3)
 - o Types of Systems
 - o Computing Environments
 - o Storage Hierarchy
 - o System Calls
 - o System Structures
 - o Virtual Machines (Java)
 - o Interrupts
2. Process Management (Chapter 4)
 - o Process Scheduling
 - o IPC
 - o Client/Server Systems
3. Threads (Chapter 5)
 - o Multithreading
 - o Difference between processes and threads
 - o Threading Issues
4. CPU Scheduling (Chapter 6)
 - o Scheduling Criteria
 - o Scheduling Algorithms
5. Process Synchronization (Chapter 7)
 - o Critical Section
 - o Synchronization using flags
 - o Hardware Methods (Test and Set)
 - o Semaphores and examples
6. Memory Management (Chapter 8)
 - o Swapping
 - o Contiguous Memory Allocation
 - o Paging, TLB
 - o Segmentation
 - o Segmentation with paging
7. Virtual Memory (Chapter 9)
 - o Demand Paging
 - o Page Replacement
 - o Allocation Frames

- o Thrashing

8. File-system Implementation (Chapter 10, 11)

- o File System Structure
- o File System Implementation
- o Directory Implementation
- o Allocation Methods

9. Mass Storage Structure (Chapter 12)

- o Disk Structure
- o Disk Scheduling

10. I/O Systems (Chapter 13)

- o I/O Hardware
- o Application I/O Interface
- o Kernel I/O subsystem
- o Streams

11. The Linux System (Chapter 21)

- o Kernel Modules
- o Process Management
- o Scheduling
- o Memory Management
- o File Systems

12. Basic Concepts (Can be studied from any source)

- o Script files
- o Batch files
- o Compilation and Linkage
- o Boot programs
- o Loader programs
- o Command Line Interpreters
- o Shell Commands
- o General OS Concepts
- o Current trends in OS

(3) Computer Networks

General Information:

- Most of the topics below are covered in introductory graduate courses on computer networks or data communications, such as COSC 650 and the AIT 620/622 sequence offered at Towson.
- While many books and websites cover these topics, we recommend the following books that are used in the above courses (PD: COSC 650, S: AIT 620, C: AIT 622).
 - (PD) Larry L. Peterson and Bruce S. Davie, *Computer Networks* (4th edition), Morgan Kaufmann, 2007.
 - (S) William Stallings, *Business Data Communications* (5th edition), Pearson Prentice Hall, 2005.
 - (C) Douglas E. Comer, *Internetworking with TCP/IP* (5th edition), Prentice Hall, 2006.

Topics:

- 9 Network Architecture (PD 1.3.1-1.3.3; S 5.1-5.3, 5.5; C 10.1-10.7.1, 10.9-10.11)
 - Layers and Protocols
 - OSI Architecture and TCP/IP Architecture
- 10 Network Performance Calculations (PD 1.5.1-1.5.4; S 2.1-2.5)
 - Transmit Time
 - Data Rates Required to Support Applications
- 11 Data Communications (PD 2.3.3, 2.4.3; S 17.5, 16.4)
 - SONET
 - Error Detection and CRC
- 12 Flow Control and Reliability (PD 2.5.1, 2.5.2; S 17.1; C 12.4, 12.5)
 - Stop-and-Wait (simple positive acknowledgement with retransmission)
 - Sliding Window
- 13 LAN Technologies (PD 2.6.2, 2.8.2, 3.2.1; S 10.2, 10.3, 11.2; C 2.4.5, 2.4.6, 2.4.8, 2.4.9, 2.4.10, 2.5)
 - Ethernet Frame Format and Address
 - 802.11 Architecture and Distribution System
 - 802.11 Collision Avoidance and Reliable Data Delivery
 - CSMA and Backoff
 - Learning Bridges and LAN Switches
- 14 IP (PD 4.1.2-4.1.5, 4.2.3, 4.3.1, 4.3.2; C 4.3-4.5, 4.11, 4.16, 5.5-5.12, 6.2-.6.7.1, 6.7.3-6.7.8, 7.2-7.10, 9.2, 9.3, 9.5-9.8, 9.10-9.12, 9.16-9.20.1, 13.9, 15.15-15.15.5)
 - IPv4 Header Format and IPv4 Addresses
 - IP Forwarding
 - IP Fragmentation
 - ARP
 - Link State Routing and OSPF Protocol
 - Subnetting and CIDR
- 15 UDP and TCP (PD 5.1, 5.2.1-5.2.7, 6.2.1, 6.3.1, 6.3.2, 6.4.2; C 11.3-11.9, 12.2-12.19, 12.22-12.33.3)
 - UDP Header Format and Checksum
 - TCP Header Format
 - Connection Establishment/Closing and State Transitions
 - Reliable Delivery and Flow Control
 - Timeout and Adaptive Retransmission Algorithms
 - Congestion Control and Avoidance

(4) Fundamentals of Software Engineering

Suggested Textbooks

- Ian Sommerville's "Software Engineering" by Addison Wesley

Suggested topics

- Software Engineering history
- Software Life-cycle Models
 - Major software processes
 - Software Process Models
- Software Quality Factors:
 - Attributes of good quality software
- Software Requirement Acquisition and Analysis
 - Requirement types
 - Requirement Elicitation and Analysis process
- Software Requirements Specification (SRS) Tools
 - Data Dictionary,
 - Data Flow Diagram,
 - Process Specification
 - Entity-Relationship Diagram,
 - UML: Use Cases, Sequence Diagram, State Chart
- Software Design
 - Architectural Design
 - Types of software architecture
 - Detailed Design
- Object Oriented Analysis and Design
 - Object Characteristics
 - Object Associations and Hierarchy
 - Services and Attributes of objects
- Software Metrics
 - Size related metrics: source lines of code
 - Complexity related metrics: Function point, Object Point, Cyclomatic Complexity
- Software Configuration Management
 - What to maintain in software
 - Change management
- Software Testing
 - Dynamic / Static
 - Black box/ White Box
 - Test Plan
 - Test Case

- Software Cost Estimation
 - Software Attributes
 - Software Cost Estimation Models
- Software Maintenance
 - Maintenance process, activities
 - Maintenance effort
- Software Reuse
- Software Re-engineering

(5) Database Management Systems

General Information:

- Most of the topics below are covered in graduate courses on database management systems I, and II. Computer science courses are COSC578, and COSC657. The equivalent AIT courses are AIT 632, and AIT 732 offered at Towson University.
- While many books and websites cover these topics, we recommend the following books that are used in the respective courses above.
 - (EN) Elmasri and Navathe, Fundamentals of Database Systems, Fifth Edition, Addison Wesley, 2006.
 - (CB) Thomas Connally, and Carolyn Begg, Database Systems, A Practical Approach to Design, Implementation, and Management, Third Edition, Addison Wesley, 2003.

AIT students can prepare for this exam using CB and CS students can prepare for this exam using EN reference. The following topics are covered in both the books.

Topics:

1. Files versus Databases (Comparison)
2. Three Schema Architecture or Three-Level ANSI-SPARC architecture
3. Data Independence
4. Database Languages, DDL, DML, DCL.
5. Data Modeling Using E-R Models (Entities, Relationships, Cardinalities), Chen's Model or UML model representation which ever is familiar to you.
6. The Relational Algebra, Selection, Projection, and Join operations. Representation of queries using relational algebra. Database Constraints.
7. SQL: Simple queries, and nested queries (Data Manipulation Only)
8. Normalization, Normal forms 1, 2, 3.
9. Disk storage, file structures, hashing, and indexing (CH13, CH14 from Elmasri & Navathe)
10. Transaction Management or Transaction Processing and Theory
11. Query Processing
12. Object Database Standards, Languages, and Design
or
Object-oriented DBMSs – Concepts and Design
13. Object-relational DBMSs Concepts only.
14. XML data models and concepts related to database.

(6) Project Management

AIT 630 (COSC630): References

Jack Gido and James P. Clements, Successful Project Management, 3d ed., South-Western, Ohio, 2006.

A Guide to the Project Management Body of Knowledge, 2000 edition, Project Management Institute, Inc., Pennsylvania, 2000.

| General Study Topics | | Gido & Clements | PMBOK |
|----------------------|--|-------------------------------|-------------------------|
| I. | General Concepts: <ul style="list-style-type: none">▪ Project Management▪ Life Cycle▪ Scope, Cost, Quality▪ Role of the Project Manager | Ch. 1, 13 Ch. 10 | Ch. 1, 2, 3 |
| II. | Time and Budget Estimating: <ul style="list-style-type: none">▪ Work Breakdown Structure▪ Scheduling▪ Budget Control | Ch. 5 Ch. 6, 7, 8 Ch. 9 | Ch. 4 Ch. 6 Ch. 7 |
| III. | Procurement: <ul style="list-style-type: none">▪ Management of the Process | Ch. 2, 3, 4 | Ch. 12 |
| IV. | Human Factors: <ul style="list-style-type: none">▪ Teams▪ Communications | Ch. 11 Ch. 12 | Ch. 9 Ch. 10 |