

D.Sc. in IT Qualifying Examination Guidelines

(updated March 2017)

1. The exam will cover the following *eight* areas:
 - A. Operating Systems (Study guide-COSC519).
 - B. Data Structures and Algorithms (Study guide-COSC600).
 - C. Database Management Systems
Study guide – COSC 578, COSC 657 or AIT 732.
 - D. Data Communications and Networking
Study guide – COSC 650.
 - E. Software Engineering (Study guide – COSC 612 or AIT 624).
 - F. Project Management
Study guide - AIT 630, COSC 609.
 - G. Human Computer Interaction
Study guide – COSC 605.
 - H. Computer Security (to be added June 2017)
Study Guide—COSC 645, COSC734

2. Date of the exam and the nature of the exam.
The D.Sc. in IT qualifying exams will be written exams and will be offered twice a year, once in January, and once in June. You can attempt all parts in the exam.

3. Evaluation Procedure
 - Four areas (out of 8; the number of sections may change in the future, but there will always be at least 6 sections) must be passed to pass the qualifying examination. Each subject has a Pass or Fail status.
 - A student can take the Qualifying Exam at most two times. The student must pass at least 4 sections (as indicated in the previous paragraph) in the two attempts combined; otherwise the committee will recommend the student for dismissal from the program.
For example, if in the first attempt, say, June 2016 a student passed two sections, then s/he has one more attempt to pass two of the other sections.
 - A student must pass the qualifying exam within the first 4 years in the program. If a student does not pass the qualifying exam within the time period, the committee will recommend the student for dismissal from the program.

4. The students will be notified of results in about two weeks after the exam.

Detail Topics for Each Subject Area

You must pass at least 4 out of 8 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.
- Operating Systems Essentials 2nd Edition Silberschatz, Galvin and Gagne, Wiley Publications

Topics:

1. Fundamentals
 - 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
 - o Process Scheduling
 - o IPC
 - o Client/Server Systems
3. Threads
 - o Multithreading
 - o Difference between processes and threads
 - o Threading Issues
4. CPU Scheduling
 - o Scheduling Criteria
 - o Scheduling Algorithms
5. Process Synchronization
 - o Critical Section
 - o Synchronization using flags
 - o Hardware Methods (Test and Set)
 - o Semaphores and examples
6. Memory Management
 - o Swapping
 - o Contiguous Memory Allocation
 - o Paging, TLB
 - o Segmentation
 - o Segmentation with paging
7. Virtual Memory
 - o Demand Paging
 - o Page Replacement
 - o Allocation Frames

- o Thrashing

8. File-system Implementation

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

9. Mass Storage Structure

- o Disk Structure
- o Disk Scheduling

10. I/O Systems

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

11. The Linux System

- 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, 7th Edition, Addison-Wesley.
 - (CB) Thomas Connally, and Carolyn Begg, Database Systems, A Practical Approach to Design, Implementation, and Management, 6th Edition, Pearson.

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 (COSC609): References

Jack Gido and James P. Clements, Successful Project Management, 5th ed., South-Western, Ohio, 2012.

A Guide to the Project Management Body of Knowledge, 5th edition, Project Management Institute, Inc., Pennsylvania, 2013.

General Study Topics	Gido & Clements	PMBOK
I. General Concepts: <ul style="list-style-type: none"> • Project management • Constraints • Life cycle • Project management process 	Ch. 1.	Ch. 1, 2
II. Initiating a Project: <ul style="list-style-type: none"> • Identification and selection • Charter • RFP & proposal development and processes • Types of contracts 	Ch. 2, 3	Ch. 3, 4
III. Planning, Performing, and Controlling a Project: <ul style="list-style-type: none"> • Defining the project objective and scope • WBS, network diagram, and other schedule aspects • Controlling and updating the schedule • Resource planning, leveling, and scheduling • Determining costs and cost performance measures • Risk management • Project closing activities 	Ch. 4, 5, 6, 7, 8, 9	Ch. 3, 4, 5, 6, 7, 8, 11
IV. Human Factors: <ul style="list-style-type: none"> • Project manager roles, skills, and development • Delegation • Change management and tracking changes • Stages of team development and effective project teams • Ethics, conflict and problem solving • Communication; project communication plan • Meetings, presentations, and reports • Project management organizational structures 	Ch. 10, 11, 12, 13	Ch. 1, 2, 9, 10

(7) Human Computer Interaction

General information:

- The topics below are covered at different level of details in the following courses offered by our department: CIS435, COSC605
- These topics are covered in many textbooks on Human-Computer Interaction and Research methodology. We recommend the following text books:
 - Shneiderman, B. and Plaisant, C. (2009). Designing the user interface: Strategies for effective human-computer interaction. Addison Wesley. 5th edition. ISBN: 0321537351
 - Lazar, J., Feng, J., and Hochheiser, H. (2010). Research methods in HCI. Wiley. ISBN: 0470723378
 - Sharp, H., Rogers, Y., and Preece, J. (2007) Interaction Design, Beyond Human-Computer Interaction. Wiley. ISBN: 0470018666.

Topics:

1. Human cognition in HCI
 - a. Human memory
 - b. Human visual perception
 - c. Human cognition relates to output
 - d. Implications for design (7+-2 rules, recognition vs. recall)
2. Human errors
 - a. Mistakes vs. slips
 - b. Types of slips
 - c. Design strategies to prevent, detect, and recover from errors
3. Input and Fitts' Law
 - a. Input technologies
 - b. Fitts' law
4. Usability
 - a. Usability concepts
 - b. Usability measures
 - c. General design guidelines and principles
5. Accessibility
 - a. Accessibility concepts
 - b. Why is accessibility important
 - c. Accessibility guidelines and regulations
6. User-centered design
7. How to know your user and evaluate your design
 - a. Requirement analysis
 - b. Ethnography
 - c. Observation
 - d. Survey
 - e. Diary
 - f. Interview
 - g. Focus group
 - h. Automated usability testing
 - i. Lab-based usability testing
 - j. Empirical studies
8. Experiment design
 - a. Dependent variables vs. independent variables
 - b. Between group design
 - c. With group design
 - d. Split-plot design
 - e. When should a specific design be used
 - f. Internal, external, and theoretical validity in experiment design
9. Hypothesis testing
 - a. Null hypothesis vs. alternative hypothesis
 - b. Type I error vs. type II error
 - c. Statistical significance

10. Statistical data analysis methods
 - a. Why do we need to run statistical analysis on our data
 - b. T test
 - c. Analysis of Variance
 - d. Correlation
 - e. Regression
 - f. Repeated measures Analysis of Variance
 - g. Non-parametric tests
 - h. Factor analysis
11. Analyzing qualitative data (primarily text-based data)
 - a. Grounded theory
 - b. How to code text-based data
 - c. How to evaluate the quality of the coding
 - d. How to interpret the data

(8) Computer Security

General Information:

- The topics below are covered at different level of details in the following course offered by our department: COSC 645 and COSC734
- These topics are standard and are covered in many textbooks on computer and network security. We recommend the following textbooks written by the same author:

(WS-N) William Stallings, Network Security Essentials, Fourth Edition, Prentice Hall, 2011. ISBN-10: 0-13-610805-9

(WS-C) William Stallings, Cryptography and Network Security – Principle and Practice, Prentice Hall, ISBN-10: 0-13-609704-9

Topics:

Notice that following listed topics are mainly based on book WS-N. However, similar materials related to Basic Compute Security Concept, Cryptography, and Network Security Applications can be found WS-C book as well.

Basic Computer Security Concept:

- Computer Security Concept (WS-N: Chapter 1.1), OSI Security Architecture (WS-N: Chapter 1.2) Security Attacks (WS-N: Chapter 1.3), Security Service (WS-N: Chapter 1.4), Security Mechanisms (WS-N: Chapter 1.5), A Model for Network Security (WS-N: Chapter 1.6)

Cryptography

- Symmetric Encryption and Message Confidentiality: Symmetric Encryption Principle (WS-N: Chapter 2.1), Symmetric Block Encryption Algorithm (WS-N: Chapter 2.2), Steam Ciphers (WS-N: Chapter 2.4)
- Public-key Cryptography and Message Authentication: Approaches to Message Authentication (WS-N: Chapter 3.1), Message Authentication Code - HMAC (WS-N: Chapter 3.2), Public-Key Cryptography Principles (WS-N: Chapter 3.4). Public-Key Cryptography Algorithm (WS-N: Chapter 3.5)

Network Security Applications

- Key Distribution and User Authentication: Symmetric Key Distribution Using Symmetric Encryption (WS-N: Chapter 4.1), Kerberos (WS-N: Chapter 4.2)
- Transport-Level Security (WS-N: Chapter 5): Security Socket Layer and Transport Layer Security (WS-N: Chapter 5.2)
- IP Security: IP Security Overview (WS-N: Chapter 8.1), Encapsulating Security Payload (WS-N: Chapter 8.3)

System Security

- Intruders: Intruders (WS-N: Chapter 9.1), Intrusion Detection (WS-N: Chapter 9.2)
- Malicious Software: Types of Malicious Software (WS-N: Chapter 10.1), Viruses (WS-N: Chapter 10.2), Virus Countermeasures (WS-N: Chapter 10.3), Worms (WS-N: Chapter 10.4), Distributed Denial of Service Attacks (WS-N: Chapter 10.5)
- Firewalls: Firewall Characteristics (WS-N: Chapter 11.2), Types of Firewalls (WS-N: Chapter 11.3), Firewall Basing (WSN: Chapter 11.4)