MASTERS COMPREHENSIVE EXAMINATION
READING MATERIAL

Revised Sp'18

FORMAT EXAMINATION

The Masters Comprehensive Examination has nine parts, one of which is further divided into subparts.

The nine parts are:

Part 1 Analysis of Algorithms (MA STUDENTS MUST TAKE THIS EXAM)
Part 2 Architecture
Part 3 Artificial Intelligence
Part 4 Database
Part 5 Management Information Systems (MS STUDENTS MUS TAKE THIS EXAM)
Part 6 Operating Systems
Part 7 Programming Languages
Part 8 Telecommunications and Networking
Part 9 Theoretical Computer Science. Questions will include, both Computability theory and Formal Language Theory.

The examination is three and a half hours long. You must answer three (3) of the nine parts.

You do not have to decide in advance which three parts you will answer. In the examination room you will receive all parts of the exam, and you can make your decision at that time.

However, it is strongly suggested that you plan in advance to answer certain parts, with the option to change your mind after seeing all of the exams.

The rules are different for M.A. students and M.S. students

M.A. students MUST take the Analysis of Algorithms examination, plus two other parts
M.S. students MUST take the Management Information Systems examination, plus two other parts

GRADING
Each part of the examination is written by a separate committee and graded by that committee.
In order to pass the Comprehensive examination, all students must pass all three parts (this includes Analysis of Algorithms for M.A.
Students, and Management Information Systems for M.S. students).

(a) Starting in Fall 2016, if you complete all the answers on three parts of the exam but only pass one part, you will have to retake the missing two parts
(b) if you fail one part and pass the other two, you will receive credit for those two parts. The next time you take the exam you will have to pass only one part

Brooklyn College Policy allows graduate students to attempt to pass the exam two (2) times

READING LISTS AND LEVEL OF THE EXAMINATION

A set of reading lists is posted outside the Department Office (2109 Ingersoll Hall) Students who expect to register for the exam this semester or next semester can request a copy of the reading list from the Office.

MASTERS COMPREHENSIVE EXAMINATION

READING MATERIAL

TOPICS FOR ANALYSIS OF ALGORITHMS

A. Discrete Structures

- Induction and Recursion
- Propositional Logic, Boolean Algebras
- Set Operations
- Properties of relations, Closures, Properties of Functions
- Countable and Uncountable Sets, Diagonalization
- Combinatorics
- Alphabets, Strings, Languages

B. Data Structures

- Linked Lists, Stacks, Queues, Graphs, Trees, Terminology and Representation
- Tree Traversal (inorder, preorder, postorder) and Graph Searching (Depth first, breadth first)
- Sorting: Insertion, Bubble, Quick, Heap, Merge, Bucket
- Binary Search Trees, B-Trees, Heaps

C. Analysis of Algorithms and Algorithmic Strategies

- Big-O Omega and Theta notations
- Upper Bound (e.g., Analysis of Heapsort) and Lower Bound For Sorting with Comparisons
- Union-Find Algorithm
- Divide and Conquer Strategy and Solving Recurrence Relations:
  - e.g. Analysis of Merge-sort, Quick-sort, K-th Selection
    Strassen's Matrix Multiplication
- Greedy Strategy
  - e.g. Minimum Spanning Tree (Prim, Kruskal). Shortest Path (Dijkstra)
- Dynamic Programming: e.g., All Pairs Shortest Paths, Discrete (0-1) Knapsack, Traveling Salesperson
- Backtracking: e.g., 8-Queens, Graph Coloring

D. Computational Complexity

- Background knowledge about Turing Machines and the Unsolvability of the Halting Problem
- Computational Complexity: Time and Space, P, NP, PSPACE
- The Concept of Problem Reduction, NP-Completeness, Satisfiability and Cook's Theorem
- Other NP-Complete Problems: e.g., Traveling Salesperson, Hamiltonian Circuit, Vertex Cover, Clique, Discrete Knapsack

TEXTBOOKS

Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, Introduction to Algorithms 3rd Ed.MIT Press, 2009. Ivan Parberry, Problems on Algorithm: http://larc.unt.edu/ian/books/free/poa.pdf

Videos by Tom Leighton about Mathematics for Computer Science

http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-042j-mathematics-for-computer-science-fall-2010/

Topics for ARCHITECTURE

Last revised on 9/22/04

A. Binary Representations of Data

- Binary Representations of Octal, Decimal and Hexadecimal digits.
- Binary Representation of Characters, ASCII code.
- Representations of Signed and Unsigned Integers and Fractions.
- Packed Decimal, 2's Complement and Signed Magnitude.
- Representations of Fixed Point and Floating Point numbers.
- IEEE Floating Point Format.

B. Design of Combinational functions and circuits

- Boolean Algebra, Truth Tables and Karnaugh Maps.
- Gates, Combinational circuits, and timing delays.
- Decoders, Multiplexers, Full and Half Adders, Full and Half Subtractors, Combinational Multiplier and Divider Circuits, and Logic Circuits, ROMs and PLAs.

C. Design of Sequential functions and circuits

- State Diagrams, State Tables and Register Transfer Language Programs.
- Flip-flops, Registers, the Clock and Timing Control.
- Registers with various operations such as: Counters, Logical and Arithmetic Shift operations, and Parallel Load operations.
- Integer and Floating Point Sequential Multiplier and Divider circuits.

D. Register Transfer Language (RTL)

- Representation of Control functions and Microoperations.
- Specification of Register and Memory transfers, Buses, Arithmetic and Logical operations.
- Translation of an RTL program into a Logic Diagram.
- Timing Signals and Control Signals.

E. Performance and Cost Analysis

- Benchmarks, Performance Measures, Performance and Execution Time, Amdahl's law, Speedup, CPU Time, Clock Cycle Time and Clock Rate, Cycles per Instruction and Instruction Count.

F. Instruction Set Principles

- Accumulator, Stack and General Purpose Architectures.
- Register-Register (or Load-Store Architecture) and Register-Memory Architectures.
- Operand Addressing Modes, Instruction Set Operations, Type and Size of Operands and the Encoding of an Instruction Set.
- RISC versus CISC.

G. Design and Performance Analysis of a non-Pipelined CPU

- An RTL Program Specifying the Fetching and Execution of Instructions.
- Operand Address Decoding.
- Interrupt Cycle.
- Hard-Wired and Microprogrammed Control Units.
- Microprogram Instructions and Formats.

- Control Words.

H. Design and Performance Analysis of a Pipelined CPU

- Relationship between an Instruction set and a Pipelined CPU.
- Pipeline Registers.
- Pipeline Data and Control Hazards.
- Stalls.
- Forwarding.
- Instruction Scheduling, Delay Slots and a Delayed Branch.
- Multicycle Operations, and Exception Handling.

I. Memory-Hierarchy Design and Performance Analysis

- Principle of Locality.
- Cache, Main Memory and Secondary Memory.
- Cache hit rate and time, miss rate and time, and miss penalty,
- Direct, Associative, and Set Associative mappings.
- Replacement Algorithms.
- Write Through and Write back Caches.
- Main Memory, the CPU-Memory Bus, Access time and Cycle time, and bandwidth.
- Design of 1-Dimensional and 2-Dimensional RAMs and DRAMs,
- Interleaved Memory and Memory Banks.
- Virtual Memory.

J. I/O and Storage System Design, and Performance Analysis

- Magnetic Disks.
- I/O Buses, Bus Masters and Synchronous and Asynchronous Buses.
- Data Transfers.
- Hand Shaking, Cycle Stealing, Bus Request and Acknowledge.
- I/O programming and Interrupt Handling.
- DMA and IOP.
- I/O Performance Measures.

K. Multiprocessors

TEXTBOOKS

1. J. Hennessy & D. Patterson, *Computer Architecture A Quantitative Approach*, 2nd Edition, Morgan Kaufmann.
2. J. Hayes, Computer Architecture, 2nd Edition, Hayes, McGraw-Hill.
3. M.M. Mano, Computer System Architecture, 3rd Edition, Prentice Hall.
4. D. Patterson and J. Hennessy, *Computer Organization and Design*, 3rd Edition, Morgan Kaufmann

Topics for ARTIFICIAL INTELLIGENCE

Last revised on 9/12/04

A. **Search Techniques:**

- Generate-and-Test approach
- Constrain-and-generate approach
- Uninformed search methods (depth-first, breadth-first, etc.)
- Branch-and-bound
- Informed search methods (best-first, beam, A*, etc.)
- Heuristics for informed search methods and constraint satisfaction problems
- Adversarial search techniques and games (Minimax, Alpha-Beta Pruning)

B. **Knowledge Representation:**

- Semantic networks
- Frames
- Production rule systems
- Neural networks and genetic algorithms

C. **Logic:**

- Propositional Logic
- First-order (predicate) logic
- Clausal form (including skolemization)
- Unification
- Resolution

D. **Applications:**

- Expert systems
- Learning
- Constraints and propagation
- Planning
- Natural language processing

TEXTBOOKS

1. G. F. Luger and W. Stubblefield, *Artificial Intelligence*, third edition, Addison-Wesley, 1998.
2. S. Russell and P. Norvig, *Artificial Intelligence - A Modern Approach* (second edition), Prentice Hall, 2003
3. P. H. Winston, *Artificial Intelligence*, Addison Wesley, 1992.
4. M. R. Genesereth and N. J. Nilsson, *Logical Foundations of Artificial Intelligence*, Morgan Kaufmann 1987.
5. C. J. Hogger, *Essentials of Logic Programming*, Oxford UP 1990.

6. B. Coppin, *Artificial Intelligence*, Jones and Bartlett, 2004

Note Russell/Norvig is useful for areas A-D, but you may wish to consult Genesereth/Nilsson or Hogger to get more background on logic. Winston is very useful for all areas except logic.

Topics for DATABASE SYSTEMS

Last revised 9/29/09

A. Introduction to Database Systems.

B. The Relational model, ER diagrams, Relational algebra.

C. Database Design.

D. Normal Forms.

E. Study of Several Real-world Database Management Systems (DBMS's).

F. SQL.

G. Query and Transaction Processing.

H. Concurrency, Recovery.

I. Distributed, Parallel, Client-server, and Object-oriented Databases.

TEXTBOOKS

Although some books may not cover all of the topics listed above, a good knowledge of any one of the books below, plus material on individual DBMS's, should be sufficient to pass the exam:

Database Systems (Seventh Edition)
authors: Coronel and Rob Cengage Learning 2006

Introduction to Database Systems (Eighth Edition)
author: Date Addison-Wesley 2003

Database System Concepts (Fifth Edition)
authors: Korth, Silberschatz, Sudrashan McGraw-Hill 2005

Databases Illuminated
author: Ricardo Jones and Bartlett 2004

MIS Comprehensive Exam – Topics and Reading List
(Revised February 2018)

Requirements elicitation processes, functional requirements, non-functional requirements, requirements analysis techniques

UML Diagrams – general definitions and creation of use-case model diagrams, activity diagrams, sequence diagrams, class diagrams and state transition diagrams

Information Systems Planning – guidelines for effective planning, tools for identification of opportunities, innovating with technology, systems for strategic advantage, development processes for strategic, tactical and operational plans

Systems Analysis – approaches, phases, fact-finding techniques including sample size determination, feasibility tests, alternate design approaches, user interface design

Telecommunications – types of networks, transmission media, transmission speed, network protocols, network topologies, OSI Reference Model, wireless technologies

Testing techniques and software quality assurance - unit testing, regression testing, equivalence class partitioning, boundary value analysis, path analysis, integration testing, smoke testing, black box testing, white box testing, risk identification/management/amelioration

Methodologies, Strategies and Tactics for Software Development and Implementation – waterfall (SDLC), prototyping, RAD, RUP, scrum, XP, agile, custom development options, purchased packages, user-developed software, combinations, conversion strategies from old to new systems, ASPs, six sigma, capability maturity model, outsourcing alternatives

Software Estimation Methods – lines of code, function point analysis, COCOMO, cyclomatic complexity

Project Adoption – project evaluation and prioritization techniques, risk identification/analysis (brainstorming, nominal group technique, Delphi method, etc.), justifying technology investments (Payback period, Break-even, Return on Investment, Net Present Value, Internal Rate of Return)

Organization structure types, organizing a framework for systems technology management

Changing nature of software, types of artificial intelligence, managerial support systems, decision support systems, executive information systems, GISs, E-commerce, enterprise-wide applications

Project Scheduling – quantitative and probabilistic – CPM and PERT calculations, types of buffers, resource leveling and smoothing, tradeoffs between methodologies

Information Systems Project Failure – major categories (Lyytinen/Hirschheim, etc.), primary reasons, impact and cost of defect removal by project phase (Boehm, etc.)

Project Control and Assessment – risk management categories, planning vs. control issues, cost/benefit and risk analyses, scope management, quality management, project closure

Exam Format:

There will be a series of relatively short questions, with some choice. The exam may have a case study, but a case study may not be present each time the exam is given. If there is a case study, there will be several questions on it. For example, you might have to answer a total of 12 out of 15 questions including two case study questions.

Suggested texts to find topics listed above

Management Information Systems: Managing the Digital Firm, 15th edition, Kenneth C. Laudon and Jane P. Laudon, Publisher: Pearson, 2018

Modern Systems Analysis and Design, 8th edition, Joseph Valacich and Joey George, Publisher: Pearson, 2017

Information Technology Project Management, 5th edition, Jack T. Marchewka, Publisher: John Wiley & Sons, 2015

Software Engineering: A Practitioner's Approach, 8th edition, Roger S Pressman and Bruce R. Maxim, Publisher: McGraw Hill, 2015

Topics for OPERATING SYSTEMS

Last revised on 11/10/11

A. OS Types and Organization

- Batch; multi-programming, time-sharing
- Multiprocessor or multicore, distributed, client-server, clustered, real-time systems
- Structure of OS – simple, layered, microkernel
- Virtual Machines
- Protection – CPU, Memory, I/O

B. Input-Output

- Interrupt, trap, interrupt vector
- Interrupt mechanism and handling, privileged instructions
- Alternatives to interrupts: busy-waiting, polling
- Buffering, DMA
- I/O Processing

C. Process Management

- Process concept and process scheduling
- Serving process requests (synchronous and asynchronous interrupts, system calls, etc.)
- Process switching mechanism
- Cooperating processes, inter-process communication, sockets, RPCs
- Multi-threading – types of threads, multi-threading models

D. CPU Scheduling

- Basic concepts
- Interactive vs. batch processing
- Scheduling criteria and algorithms - First Come First Served, Shortest Job First, Priority, Round-Robin, Multi-level Queue, Multi-level Feedback Queue

E. Process Synchronization

- Critical section problem, synchronization hardware and primitives, semaphores, monitors, mutex locks
- Classical problems of synchronization: Bounded-Buffer, Producer-Consumer, Readers-Writers, Dining Philosophers

F. Deadlocks

- Conditions, prevention, avoidance, detection & recovery
- Resource allocation graphs, Banker's Algorithm

G. Memory Management

- Logical vs. physical memory
- Memory management hardware
- Memory allocation – MFP, MVP (best-fit, worst-fit, first-fit), internal and external fragmentation
- Paging: page table organization, special hardware support, page table structure (hierarchical, hashed, inverted), shared pages
- Segmentation: segmentation implementation, shared segments, segmentation with paging
- Virtual memory: demand paging, pre-paging, page replacement algorithms (FIFO, Optimal, LRU, Additional reference bits, Second Chance/Clock), allocation of frames, thrashing, working set theory and its application to paging, program structure

H. Mass Storage Structure

- File systems and their implementations
- Magnetic disk hardware, seek time, rotational latency
- Other types of storage devices
- Disk Scheduling Algorithms - First Come First Served, Shortest Seek Time First, SCAN, C-SCAN, LOOK, C-LOOK

TEXTBOOKS

1. Silberschatz & Galvin, *Operating Systems Concepts*, Addison-Wesley, 2003, 6th edition
2. Tanenbaum, *Modern Operating Systems*, Prentice-Hall, 2001, 2nd edition
3. Stallings, *Operating Systems Internals and Design Principles*, Prentice-Hall, 2001, 4th edition

Topics programming languages, SPRING 2018

Previous Compilers

Compiler and Programming Languages Reading List
Spring 2018

Compilers

- regular expressions
- finite automata
- context-free grammar
- recursive-descent parsing
- storage organization
- activation record
- parameter passing
- symbol table
- dynamic storage allocation

OOP

- state (instance variable, data members) / behavior (methods, member functions) of a class
- class, instance/class variables
- data access: public / private / protected
- Inheritance (is-a) vs Composition (has-a)
- upcasting, downcasting
- message passing, receiver, this
- constructors: default constructors
- get/set methods
- high-level vs low-level classes/methods
- overloading/overriding
- polymorphism
- reading/writing objects for persistence
- super/subclasses; super/subinterfaces
- abstract classes and methods
- OOP languages (Java and C++)

Functional Programming

- types
- pattern-matching
- recursion
- lambda expressions
- polymorphism
- higher-order functions
- FP languages (Haskell and Python)

Recommended reading for the fall semester:

- Aho, A., Lam, M., Sethi, R., Ullman, J., Compilers: Principles, Techniques, & Tools, Addison Wesley, 2007.
- Timothy Budd , "An Introduction to Object-Oriented Programming" (3rd Edition)

Text #1 Chapter 22: Distributed Applications Text #1: Data and Computer Communications – 7th ed.

Author: William Stallings Publisher: Prentice-Hall

Text #2: Computer Networking – 2nd ed.

Authors: James Kurose and Keith Ross Publisher: Addison Wesley

Text #1 Chapter 1: Data Communications and Networking Overview

or

Text #2 Chapter 1: Computer Networks and the Internet

Text #1 Chapter 2: Protocol Architecture

or

Text #2 Chapter 1: Computer Networks and the Internet

Text #1 Chapter 3: Data Transmission

Text #1 Chapter 4: Guided and Wireless Transmission

Text #1 Chapter 5: Signal Encoding Techniques

Text #1 Chapter 6: Digital Data Communication Techniques

***Text #1** Chapter 7: Data Link Control*

Text #1 Chapter 8: Multiplexing

Text #1 Chapter 9: Spread Spectrum

Text #1 Chapter 10: Circuit Switching and Packet Switching

Text #1 Chapter 11: Asynchronous Transfer Mode

Text #1 Chapter 14: Cellular Wireless Networks

Text #1 Chapter 15: Local Area Networks Overview

Text #1 Chapter 16: High Speed LANs

Text #1 Chapter 17: Wireless LANs

Text #1 Chapter 18 and Chapter 19 (section 19.2 only): Internetwork Protocols and Operation

or

Text #2 Chapter 4: Network Layer and Routing (exclude sections 4.8 and 4.9)

Text #1 Chapter 20: Transport Protocols

or

Text #2 Chapter 3: Transport Layer

or

Text #2 Chapter 2: Application Layer

Text #1 Appendix B: Fourier Analysis

Information Technology Project Management, Jack T. Marchewka, 3rd Edition, John Wiley & Sons, 2009

Information Systems Solutions: A Project Approach, 1st Edition, Richard L. Van Horn, Albert B. Schwarzkopf, R. Leon Price, McGraw Hill, 2006

The Mythical Man Month, F. P. Brooks, Anniversary Edition (second edition) Addison-Wesley, 1995

Topics For The

Last updated March 2016

Theoretical Computer Science

Section

Texts:

1. *Introduction to the Theory of Computation* by Michael Sipser. (Any Edition)
2. *An Introduction to Formal Languages and Automata* Fifth Edition by Peter Linz.
3. *Automata and Computability* by Dexter C. Kozen.

Topics	Subtopics	Sipser	Linz	Kozen
		FORMAL LANGAUGE THEORY		
Introductory Material		Sec 0.2		
	• Why Formal Languages			Chap 1
	• Sets, Alphabets, Languages		Sec 1.2	
Finite Automata		Sec 1.1, 1.2		
	• Basic Definitions		Sec 2.1	Chap 3
	• Deterministic FA		Sec 2.1	
	• Nondeterministic FA		Sec 2.2	Chap 5
	• epsilon-Transition			
Regular Languages		Sec 1.3		
	• Regular Expressions		Sec 3.1	Chap 9
	• From Reg. exp. to FA		Sec 3.2	
Context-Free Languages		Sec 2.1		
	• Context-Free Grammars		Sec 5.1	Chap 19
	• Derivations, Parsing, Trees		Sec 5.1	
	• Regular Grammars		Sec 3.3	
	• Chomsky Normal Form		Sec 6.2	Chap 21
Push-Down Automata		Sec 2.2		
	• From CFG to PDA		Sec 7.2	Chap 24
		COMPUTABILITY THEORY		
Turing Machines		Chapter 3		
	• Basic Definitions		Sec 9.1	Chap 28
	• Variations of TM		Chap 10	Chap 29,30
	• Church Turing Thesis		Sec 9.3	Chap 28
Decidability		Chapter 4	Chapter 12	
	• Decidable Problems			
	• The Halting Problem			
		COMPLEXITY THEORY		
Time Complexity			Chap 14	
	• Measuring Complexity	Sec 7.1		
	• The Class P	Sec 7.2		
	• The Class NP	Sec 7.3		
	• NP-Completeness	Sec 7.4		
	• Additional NP-complete Prbs	Sec 7.5		
Space Complexity				
	• The class PSPACE	Sec 8.2		