IIIS - Preliminary Exam - Theory

IIIS graduate students who work in algorithms, computational complexity and cryptography should take this exam.

Rules:
(1)You have 3 hours.
(2)In order to pass, PhD students should get at least 60 points.
Master students should get at least 50 points.
(3)Closed-book. The student can bring 5 A4 pages with whatever is written/printed on it. No books, computers, cellphones.

Scope:

Math:
Everything that you learn from the calculus, linear algebra and probability course.

Algorithms: (60 points)
(1) Sorting
    bubble sort, insertion sort, mergesort, heapsort, quicksort
(2) Basic Data Structures
    Binary search tree (CLRS Ch.12)
    B-tree (CLRS Ch.18)
    Union-Find Set (CLRS Ch. 21)
(3) Basic graph problems
    BFS, DFS
    Connected components
    Strongly connected components
    Directed acyclic graphs and topological order (CLRS 22.4, 22.5)
(4) Minimum spanning tree
    Prim Algorithm (KT 4.5,4.6)
    Kruskal Algorithm (KT 4.5,4.6)
    Can use MST to model and solve other problems
(5) Shortest Path
    Dijkstra Algorithm (KT 4.4)
    Bellman-Ford Algorithm (KT 6.8,6.9)
    Floyd-Warshall Algorithm (CLRS 25.2))
    Can use Shortest Path to model and solve other problems
(6) Dynamic Programming (KT Ch.6, CLRS Ch.15)
    Can use DP to solve problems.
(7) Greedy Algorithms (KT Ch.4, CLRS Ch.16)
    Interval scheduling (KT 4.1)
    Scheduling to minimize lateness (KT 4.2)
    Huffman codes (KT 4.8)

Matroids (CLRS 16.4, 16.5)

(8) Divide and Conquer

Quick-sort (CLRS Ch.7)

Merge-sort and variants (KT 5.1, 5.3)

Maximum Subarray (CLRS 4.1)

Solving recurrence (KT 5.2, CLRS 4.3)

(9) Hash Table (CLRS Ch.11)

Chaining

Open addressing

Universal hashing

Perfect Hashing

More importantly know how to use it in applications.

(10)Matching

Hungarian Algorithm (KT 7.5)

Hall's Theorem (KT 7.5)

Know non-bipartite graph matching can be solved in poly-time (no proof).

Can use matching to model and solve other problems

(11) Flow

Ford-Folkson Algorithm (KT 7.1)

Max flow and min cut theorem (KT 7.2)

Flow with multiple sources/sinks and capacity lowerbounds (KT 7.7)

know min-cost matching can be solved in poly-time (KT 7.13)

Can use matching to model and solve other problems (e.g., KT 7.5-7.12)

(12) Basic Linear Programming (CLRS Ch. 29)

Simplex method

Duality

(13) Approximation Algorithms (CLRS Chapter 35 and KT Chapter 11)

Vertex Cover (KT 11.4, KT 11.6)

k-center (KT 11.2)

Set Cover (KT 11.3)

Knapsack (KT 11.8)

Linear programming and randomized rounding (CLRS 35.4)

(14) Randomized Algorithm (CLRS Chapter 5 and KT Chapter 13)

Min-cut (KT 13.2)

MAX 3-SAT (KT 13.4)

Randomized Divide and Conquer (KT 13.5, CLRS 7.3, CLRS 9.2)

Chernoff Bounds (KT 13.9)

Load Balancing (KT 13.10)

(15) Basic Metric Embedding

Johnson-Lindenstrauss Lemma ([JL])

Probabilistic tree embedding (no proof) and applications to approximation algorithms ([AA])

Bourgain's Theorem [Bo]

(16) Basic Streaming Algorithms

Frequent Items [SA Lec.1]

Count-Min Sketch [SA Lec.3]
AMS Sketch [SA Lec.5]

References:
[KT] Algorithm Design, by Kleinberg andTardos
[CLRS] Introduction to Algorithms, 3rd Edt. by CLRS
[JL] http://www.cs.cmu.edu/~anupamg/metrics/lectures/lec15.ps
[AA]B. Awerbuch and Y. Azar, Buy-at-bulk network design, FOCS '97.
[Bo]http://www.cs.princeton.edu/courses/archive/spring05/cos598B/lecture10.pdf
[SA]http://www.cs.dartmouth.edu/~ac/Teach/CS85-Fall09/Notes/lecnotes.pdf

Complexity: (40 points)
(1) Definitions (and basic properties) of Turing Machines and Combinatorial circuits [AB Ch. 1]
(2) NP hardness (AB Ch.2)
(3) Time/Space Hierarchy Theorem [AB Thm 3.1 and 3.2]
(4) PSPACE and NL (AB Ch. 4)
(5 Inductive counting: NL=coNL (AB Ch 4.2.3)
(6) RP, ZPP, BPP (AB. Ch 7)
(7) Randomized Algorithm for undirected st-connectivity (AB Thm 7.19)
(8) Yao's min-max lemma and applications (AB Ch 12.4.1)
(9) Parity not in AC^0 (AB Thm 14.1)
(10) Random Walks and basic spectral graph theory (AB Ch 21.1-21.2)
(11) Basic applications of expanders to derandomization (AB. Ch 20.1-20.2)
(12) Basic constructions of extractors (AB. Ch 21.5)
(13) Basic Coding Theory and application to hardness amplification, Yao's XOR lemma (Thm 19.2)
(14) The statement (no proof) of the PCP theorem and application to hardness of approximation (AB 11.1-11.4)

Reference:
[AB] Computational Complexity: A Modern Approach, By Sanjeev Arora and Boaz Barak

Cryptography and Security: (40 points)
(1) Classic ciphers and their cryptanalysis (KL Ch.1)
(2) Symmetric Cryptographic Primitives: OWFs, OWPs, PRGs, PRFs, PRPs (KL Ch.2, G1 Ch.6)
(3) Goldreich-Levin Theorem, Construction of PRGs from OWPs and Hybrid Argument [G1 Ch.3]
(4) Constructions of PRFs from PRGs (GGM), PRPs from PRFs (Luby-Rackoff) [G1 Ch. 6]
(5) Leftover Hash Lemma, Universal and Pairwise-Independent Hash Functions (AB)
(6) Message Authentication Codes, Universal One-way (and Collision-Resistant) Hash functions [KL Ch.4]
(7) Block Ciphers: AES and DES, differential and linear cryptanlaysis (KL Ch.5)
(8) Digital Signatures and Random Oracles [KL Ch.12]
(9) Zero Knowledge Proof Systems [G1 Ch.4,]

(10) Number Theoretic Assumptions, Discrete Logarithm, RSA and Diffie-Hellman (KL Ch.7)
(11) Public-Key Encryptions: (insecurity of text-book) RSA, El Gamal, and trapdoor permutations. (KL Ch.10)
(12) Side-channel Attacks and Countermeasures (MOP)

References:
[G1] Foundations of Cryptography: Volume 1, By Oded Goldreich.
[G2] Foundations of Cryptography: Volume 1, By Oded Goldreich.
[KL] Introduction to Modern Cryptography: by Jonathan Katz and Yehuda Lindell.
[MOP] Power Analysis Attacks: Revealing the secrets of smartcards, by Stefan Mangard, Elisabeth Oswald, Thomas Popp

IIIS Graduate Program Committee
April 2013

IIIS – Preliminary Exam – Computer Systems

IIIS Graduate students who work in computer systems related field should take this exam.

Goal of the exam

1) Ensure the student has a solid undergraduate-level knowledge on the core concepts and methods in operating systems, and computer networking.
2) Ensure the student has the ability to read, understand and present a research paper in computer systems area.

Rules

1) The system preliminary exam committee conducts this exam once per semester. Typical length of the exam is 2 hours written exam + 45 minutes oral exam.
2) The format of the exam is:
    a. 2-hour written exam on the fundamental knowledge on computer systems. Both questions and answers will be in English.
    b. 25 minutes oral presentation, in English, on a conference-length research paper, which is assigned to the student no less than 48 hours before the exam. 20 minutes Q&A oral exam will follow the paper presentation. Master students may request Chinese version of oral exam, upon approval from graduate study committee (see below for impact on the score).
    c. Total score for the exam is 100. The written part counts for 70% of the final score, and oral part counts for 30%. Taking Chinese version of the oral will cost the student 33% on the oral exam. I.e. the max score given to a Chinese version of oral will be 20 out of 30.
3) Two or more faculty members must be present at the oral exam to ensure fairness. Each faculty member will independently score student's performance on a scale of 1-30. The student's final oral score will be the arithmetic average of all scores received.
4) The exam committee chair will file proposed questions, reading assignment and grading standard at least a week before the exam to the graduate study committee for approval.
5) Ph.d. student must receive a score 75 or higher to pass. Master's student will need a score of 60 or higher to pass.
6) Should there be any changes to the syllabus, the graduate study committee must notice the students at least 3 month prior to the change.

Syllabus

The exam focuses on operating systems, computing networking and database systems. The syllabus is based on ACM's recommended curriculum (2008 version), available at http://www.acm.org//education/curricula/ComputerScience2008.pdf .

1. Operating Systems

OS/OverviewOfOperatingSystems

• Role and purpose of the operating system
• History of operating system development
• Functionality of a typical operating system
• Mechanisms to support client-server models

• Design issues (efficiency, robustness, flexibility, portability, security, compatibility)

OS/OperatingSystemPrinciples
• Structuring methods (monolithic, layered, modular, micro-kernel models)
• Abstractions, processes, and resources
• Concepts of application program interfaces (APIs)
• Application needs and the evolution of hardware/software techniques
• Device organization
• Interrupts: methods and implementations
• Concept of user/system state and protection, transition to kernel mode

OS/Concurrency
• States and state diagrams
• Structures (ready list, process control blocks, and so forth)
• Dispatching and context switching
• The role of interrupts
• Concurrent execution: advantages and disadvantages
• The "mutual exclusion" problem and some solutions
• Deadlock: causes, conditions, prevention
• Models and mechanisms (semaphores, monitors, condition variables)
• Producer-consumer problems and synchronization
• Multiprocessor issues (spin-locks, reentrancy)

OS/SchedulingAndDispatch
• Preemptive and nonpreemptive scheduling
• Schedulers and policies
• Processes and threads
• Deadlines and real-time issues

OS/MemoryManagement
• Review of physical memory and memory management hardware
• Paging and virtual memory
• Working sets and thrashing
• Caching

OS/SecurityAndProtection
• Overview of system security
• Policy/mechanism separation
• Security methods and devices
• Protection, access control, and authentication
• Backups

OS/FileSystems
• Files: data, metadata, operations, organization, buffering, sequential, nonsequential

• Directories: contents and structure
• File systems: partitioning, mount/unmount, virtual file systems
• Standard implementation techniques
• Memory-mapped files
• Special-purpose file systems
• Naming, searching, access, backups

2. Computer Networking

NC/Introduction
• Background and history of networking and the Internet
• Network architectures
• Networks and protocols
• Distributed computing
• Client/server and Peer to Peer paradigms
• Mobile and wireless computing

NC/NetworkCommunication
• Network standards and standardization bodies
• The ISO 7-layer reference model in general and its instantiation in TCP/IP
• Overview of Physical and Data Link layer concepts (framing, error control, flow control, protocols)
• Data Link layer access control concepts
• Internetworking and routing (routing algorithms, internetworking, congestion control)
• Transport layer services (connection establishment, performance issues, flow and error control)

NC/NetworkSecurity
• Fundamentals of cryptography (Secret-key algorithms, Public-key algorithms)
• Authentication protocols
• Digital signatures
• Network attack types: Denial of service, flooding, sniffing and traffic redirection, message integrity attacks, identity hijacking, exploit attacks (buffer overruns, Trojans, backdoors), inside attacks, infrastructure (DNS hijacking, route blackholing, misbehaving routers that drop traffic), etc.)
• Use of passwords and access control mechanisms
• Basic network defense tools and strategies (Intrusion Detection, Firewalls ,
Kerberos, Network Address Translation, Auditing and logging)

NC/WebOrganization
• Web technologies (Server-side programs, Client-side scripts)
• Characteristics of web servers (Capabilities of common server architectures)
• Role of client computers
• Nature of the client-server relationship
• Web protocols
• Developing Internet information servers
• Publishing information and applications

• Grid Computing, cluster, mesh
• Web Services, Web 2.0, ajax

NC/NetworkedApplications
• Protocols at the application layer
• Web interfaces: Browsers and APIs
• Web Search Technologies
• Principles of web engineering
• Database-driven web sites
• Remote procedure calls (RPC)
• Lightweight distributed objects
• The role of middleware
• Support tools
• Security issues in distributed object systems
• Enterprise-wide web-based applications (Service-oriented Architectures)

3. Database Systems
IM/DatabaseSystems
• History and motivation for database systems
• Components of database systems
• DBMS functions
• Database architecture and data independence
• Use of a declarative query language

IM/DataModeling
• Data modeling
• Relational data model
• Semistructured data model (expressed using DTD or XMLSchema, for example)

IM/Indexing
• The massive impact of indexes on query performance
• The basic structure of an index;
• Keeping a buffer of data in memory;

IM/RelationalDatabases
• Mapping conceptual schema to a relational schema
• Entity and referential integrity
• Relational algebra and relational calculus

IM/QueryLanguages
• Overview of database languages
• SQL (data definition, query formulation, update sublanguage, constraints, integrity)
• Stored procedures

IM/RelationalDatabaseDesign

• Database design
• Functional dependency
• Decomposition of a schema; lossless-join and dependency-preservation properties of a decomposition
• Candidate keys, superkeys, and closure of a set of attributes
• Normal forms (1NF, 2NF, 3NF, BCNF)

IM/TransactionProcessing
• Transactions
• Failure and recovery
• Concurrency control

IM/PhysicalDatabaseDesign
• Storage and file structure
• Indexed files
• Hashed files
• Signature files
• B-trees
• Files with dense index
• Files with variable length records
• Database efficiency and tuning

Recommended readings

The recommended reading includes three undergraduate level textbooks and sixteen classic research papers. Students only need to read chapters covered in the syllabus. Most of the topics in the paper-list are also covered in the textbooks. The purpose of the papers is to provide training materials for paper-reading and presentation ability. Student should expect a paper in similar style and difficulty for the oral part of the exam.

现代操作系统(英文版第 3 版)
Modern Operating Systems
Anderw S.Tanenbaum
机械工业出版社 影印版 (2011 年 8 月 1 日)

Database System Concepts
Abraham Silberschatz, Henry Korth, S. Sudarshan
McGraw-Hill Science/Engineering/Math; 6 edition (January 27, 2010)

计算机网络:系统方法(英文版)(第 5 版)
Computer Networks, Fifth Edition: A Systems Approach
Larry L. Peterson and Bruce S. Davie
Morgan Kaufmann; 5 edition (March 25, 2011)
机械工业出版社; 影印版 (2012 年 4 月 1 日)

Required Paper Reading List

1) Virtual Memory Management in the VAX/VMS Operating System
H.M. Levy, and P.H. Lipman
IEEE Computer
Vol. 15, No. 3 (March 1982), pp. 35-41

2) A Fast File System For UNIX
M.K. McKusick, W.N. Joy, S.J. Leffler, and R.S. Fabry
ACM Transactions on Computer Systems
Vol. 2, No. 3 (August 1984), pp. 181-197

3) The Transaction Concept: Virtues and Limitations
Jim Gray
Proceedings of the Seventh International Conference on Very Large Data Bases
September 1981, pp. 144-154

4) Recovery Techniques for Database Systems
J.S.M. Verhofstad
Computing Surveys
Vol. 10, No. 2 (June 1978), pp. 167-195

5) End-to-end Arguments in System Design
J. Saltzer, D. Reed, and D. Clark,
ACM Transactions on Computer Systems (TOCS), Vol. 2, No. 4, 1984, pp. 195-206.

6) Experience with Processes and Monitors in Mesa
B.W. Lampson, and D.D. Redell
Communications of the ACM
Vol. 23, No. 2 (Feb 1980), pp. 105-117

7) Implementing Remote Procedure Calls
A.D. Birrell, and B.J. Nelson
ACM Transactions on Computer Systems
Vol. 2, No. 1 (Feb 1984), pp. 39-59

8) Design and Implementation of the Sun Network Filesystem
R. Sandberg, D. Goldberg, S. Kleiman, D. Walsh, and B. Lyon
USENIX Summer Conference Proceedings
June 1985, pp. 119-130

9) Measurements of a Distributed File System
M.G. Baker, J.H. Hartman, M.D. Kupfer, K.W. Shirriff, and J.K. Ousterhout
Proceedings of the 13th ACM Symposium on Operating Systems Principles
October 1991, pp. 198-212

10) Time, Clocks, and the Ordering of Events in a Distributed System,
L. Lamport
Communications of the ACM
Vol. 21, No. 7 (July 1978), pp. 558-565

11) Grapevine: An Exercise in Distributed Computing
A.D. Birrell et al.
Communications of the ACM
Vol. 25, No. 4 (April 1982), pp. 260-274

12) Operating System Support for Database Management
Michael Stonebraker
Communications of the ACM
Vol. 24, No. 7 (July 1981), pp. 412-418

13) Kerberos: An Authentication Service for Open Network Systems
J.G. Steiner, C. Neuman, and J.I. Schiller
USENIX Winter Conference Proceedings
Feb 1988, pp. 191-202

14) UNIX Implementation
K. Thompson
The Bell System Technical Journal
Vol. 57, No. 6 (July-August 1978), Part 2, pp. 1931-1946

15) Hints for Computer System Design,
B.W. Lampson
Proceedings of the 9th ACM Symposium on Operating Systems Principles
October 1983, pp. 33-48

16) The Design Philosophy of the DARPA Internet Protocols
D. Clark
SIGCOM'88, 106-114, Palo Alto, CA, Sept 1988.

IIIS - Preliminary Exam - Network

IIIS graduate students who work in networks, control, communications and systems, should take this exam.

Rules:

(1) The exam will be given every semester in English. It is closed-book. The students can bring 5 A4 pages with notes. No books, computers, or cellphones.

(2) The exam is typically 2 hours and 45 minutes long and consists of two parts. The first part is a 2-hour written exam with a total score of 65. The second part is a 45-min long oral exam given by 2-3 faculty members with a total score of 35. For the oral exam, the students will choose two areas from the followings: network/system analysis, communication/information theory, and algorithm design. The faculty members will ask area-related questions and independently score the student (1-35). The final score of the oral exam will be the average score.

(3) Ph.D. students should score at least 75 in order to pass the exam. Master students should score at least 50 for passing the exam.

(4) The graduate committee will inform the graduate students at least 3 month ahead should there be any changes in the scope.

Scope:

Math:

[1] Probability

[2] Linear algebra

[3] Mathematical analysis

[4] Calculus

[5] Abstract algebra

Network/Analysis knowledge:

Part I

[1] Computer Network and Internet (KR Ch. 1)
- Basic Internet Knowledge
- Packet Switching, Circuit Switching
- Delay, Loss, Throughput
- Layered Architecture (OSI layering model)

[2] Application Layer (KR Ch. 2)
- Web, HTTP
- FTP, SMTP, DNS, P2P
- Socket Programming

[3] Transport Layer (KR Ch. 3)
- UDP
- Reliable Data Transfer: Stop-and-wait, Go-Back-N, Selective Repeat
- TCP and Congestion Control

[4] Network Layer (KR Ch. 4)

- Virtual Circuit
- Internet Protocol (IP), IPv4, IPv6, ICMP
- Routing Algorithms, Link-State, Distance-Vector, RIP, OSPF, BGP
- Broadcast and Multicast

[5] Link Layer (KR Ch. 5)
- Error-Detection/Correction
- Random Access, CSMA, Aloha, Slotted Aloha
- Multiprotocol Label Switching (MPLS)
- Data Center Networking

[6] Wireless and Mobile Networks (KR Ch. 6)
- CDMA, 4G LTE
- 802.11 WiFi, Bluetooth, Zigbee
- Mobility, Mobile IP, Handoffs

[7] The Exponential Distribution and the Poisson Process (R Ch. 5)
- Definition, Memoryless Properties
- Splitting and Merging of Poisson Processes

[8] Markov Chain (R Ch. 4)
- Continuous Time MC, Discrete Time MC, Hidden MC
- Steady State Distribution, Time Reversibility, Return Time

[9] Renewal Theory (R Ch. 7)
- Limit Theorem
- Renewable Reward Processes
- Inspection Paradox

[10] Queueing Theory (R Ch. 8)
- Erlang's Loss System
- M/M/k, M/G/1, B/B/1

[11] Basic Graph Problems and Algorithms (Refer to Theory Exam, Algorithm 3, 4, 5, 10)

[12] Basic Knowledge of NP-Complete

[13] Linear Programming and Dynamic Programming (Refer to Theory Exam, Algorithm 6, 12)

[14] Algebraic Coding Theory
- Basic Concepts of Error Correcting Codes
- Basic Coding Bounds
- Hamming Codes, Reed-Solomon Codes

[15] Modern Coding Theory
- Fountain Codes, LDPC Codes
- Belief Propagation

[16] Information Theory (CT Ch. 2, 3, 5, 7)
- Basic Information Measures
- Source Coding Theorem
- Channel Coding Theorem

Part II

[1] Network Optimization

- Mathematical Modeling and Network Algorithm Design
- Gradient/Subgradient Descent, Convergence Analysis (BV Ch. 9, B Ch. 6)
- Duality, Decomposition techniques (BV Ch. 5, BXMM)
- Stochastic Analysis

Communication/Information Theory

- Information measures, Data compression (CT Ch. 2, 5, G Ch. 2)
- Modulation/Demodulation, Random process (G Ch. 6, 7)
- Gaussian channels, Detection, Coding/Decoding (CT Ch. 7, 8, 9, G. Ch. 8)
- Wireless communication (G. Ch. 9)

[2] Algorithm Design

- LP Duality, Rounding Technique, Primal-Dual Schema (V Ch. 12, 14, 15)
- Moments and Deviations, Tail Inequalities, and Online Algorithms (MR Ch. 3, 4, 5, 13))
- Basic Network Algorithms: leader election, MST, maximal IS (MR Ch. 4, 15)

References:

[1] Computer Networking: A Top-Down Approach, James Kurose and Keith Ross (KR)

[2] Introduction to Probability Models, Sheldon Ross (R)

[3] Convex Optimization, Stephen Boyd and Lieven Vandenberghe (BV)

[4] Notes on Decomposition Methods, Stephen Boyd, Lin Xiao, Almir Mutapcic, and Jacob Mattingley. http://www.stanford.edu/class/ee364b/notes/decomposition_notes.pdf (BXMM)

[5] Convex Analysis, Dimitri Bertsekas (B)

[6] Approximation Algorithm, Vijay Vazirani (V)

[7] Randomized Algorithms, Rajeev Motwani and P. Raghavan (MR)

[8] Distributed algorithm, Nancy Lynch (L)

[9] Elements of Information Theory, Thomas M. Cover and Joy A. Thomas (CT)

[10] Principles of Digital Communication, Robert G. Gallager (G)

IIIS Graduate Program Committee

April 2013

IIIS - Preliminary Exam – Machine Intelligence

IIIS graduate students who work in general AI, including machine learning, game theory, machine translation and computational biology, should take this exam.

Rules:
(1) You have 3 hours.
(2) In order to pass, PhD students should get at least 60 points.
Master students should get at least 50 points.
(3) Closed-book. The student can bring five A4 pages with whatever is written/printed on it. No books, computers, cellphones.

General requirements (60%):

1. Algorithms (Please refer to the requirement for the Theory Qualify exam, Algorithm 1-10)
2. Solving problem by search (AI Book Chapter 3)
3. Beyond Classic search (AI Book Chapter 4)
4. Quantifying uncertainty (AI Book Chapter 13)
5. Probabilistic reasoning (AI Book Chapter 14)
6. Learning from examples (AI Book Chapter 18)
7. Learning probabilistic models (AI Book Chapter 20)

Reference:
Artificial Intelligence: a modern approach. Third Edition. Stuart Russell and Peter Norvig

Sub-area #1 (40%): Machine Learning

1. ML core questions: (30%)

- Maximum likelihood
- EM/MCMC
- Hidden Markov Model
- Clustering and unsupervised learning
- Kernel methods
- Neural network
- Linear regression
- Support Vector Machine
- Ensemble learning
- Cross-validation
- Graphical models: Bayesian network and undirected graphical models

2. ML advanced (theory and application) questions: (10%)

- Alignment solution
- Language model and smoothing

- Context free grammar
- Bayes decision rule and Bayes risk
- Latent Dirichlet Allocation
- PAC learning
- Online learning
- (VC dimension)

Note: ML core questions are shared by sub-area 1 and sub-area 3. In parentheses, there are optional questions and readings.

Reference Books:
a) Pattern Recognition and Machine Learning. Christopher M. Bishop. Section 1.5, 1.6, 2, 4.1, 4.2, 4.3, 5, 6, 7.1, 8, 9, 11, 13, 14.
b) Foundations of Machine Learning. Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar. Section 2.1, 2.2, 2.3, 2.4, (3.3), 7.1, 7.2 (in total 29 pages)
c) The Elements of Statistical Learning Data Mining, Inference, and Prediction. Trevor Hastie, Robert Tibshirani, Jerome Friedman. 2008. Chapters 2, 3, 4, 8, 12, 14, 15, 16, 17
d) http://www.statmt.org/book/

Sub-area #2 (40%): Game theory and Computational Economics
Normal form games; computing solution concept in normal form games; extensive form game; beyond the normal and extensive form; Social Choice, Mechanism design, Auction

Reference book.
Multiagent-systems: algorithmic, game theoretic and logical foundations. Yoav Shoham and Kevin Leyton Brown. Chapters 3, 4, 5, 6, 9, 10, 11

Sub-area #3 (40%): Machine Learning and Computational Biology
Machine Learning questions (30%)

Please refer to ML Topics in sub-area #1.

Basic background about cell biology (10%)

Reference Book:
Molecular Biology of the Cell. B. Alberts, et al. 2007. Chapter 1-3.

IIIS Graduate Program Committee
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