

Ph.D. Program in Computer Science
Organized in co-operation with
Dipartimento di Informatica – Università del Piemonte Orientale

Admission test and syllabus

On the basis of past experience, the Committee for the Ph.D. Program in Computer Science believes that the admission test has to achieve two main goals:

- evaluate the attitude and the potential of the candidate in carrying on research
- test the competence of the candidate in a number of areas of Computer Science.

For this reason the first test (written examination) includes two parts:

- a short dissertation on a research topic assigned by the Selection Committee
- answering four of the eight questions covering a topic in each of the areas of

For each area, a short syllabus is included with a reference to classical textbook(s).

1) Algoritmi, calcolabilità e complessità

Macchine di Turing. Macchine a registri. Funzioni ricorsive. Tesi di Church. Funzioni non calcolabili e problemi indecidibili. Macchine di Turing universali. Il problema della fermata. Complessità computazionale di algoritmi e problemi. Delimitazioni inferiori e superiori alla complessità. Classi di complessità: P, NP, PSPACE. NP-completezza. Tecniche di progetto di algoritmi: divide et impera, backtracking, greedy, programmazione dinamica. Strutture dati fondamentali: liste, code, pile, alberi di ricerca, tabelle, grafi. Algoritmi fondamentali: ricerca, ordinamento, visita di grafi

Testi consigliati:

A.J. Kfoury, R.N. Moll, M.A. Arbib "A Programming Approach to Computability", Springer-Verlag, 1982.

T.H. Cormen, C.E. Leiserson, R.L. Rivest "Introduction to algorithms", MIT Press, 1990.

2) Computer Architecture and Operating Systems

Main concepts of computer architecture

1. Computer Systems Organization: Multi-level machines.
2. Digital Logic Level: basic combinatorial and sequential circuits
3. The Microarchitecture Level.
4. The Instruction Set Architecture Level (instruction format, addressing schemas, instruction types, control flow)
5. Parallel Computer Architectures

Main concepts of operating systems:

1. Process Management: Processes and Threads, CPU Scheduling, Process synchronization, Deadlocks
2. Memory Management: Main Memory, Virtual Memory,
3. Storage Management: File system (interface and implementation), Mass-Storage structure, I/O systems
4. Network Operating Systems (network file systems,
5. Distributed Operating Systems (general principles, the Client/Server model, Remote Procedure Call, process coordination in distributed systems)

Reference textbooks:

A. Tanenbaum: "Structured Computer Organization" 4th edition, Prentice hall, 1999.

A. Tanenbaum: "Modern Operating Systems, 2nd Ed.", Prentice Hall 2002

A. Silberschatz, P.B. Galvin, and G. Gagne. "Operating System Concepts (VI Ed. or VII Ed.)", Addison Wesley.

3) Automata, Formal languages and Compilers.

Regular expressions, regular languages and finite automata. Context- free languages, push-down automata. Chomsky Hierarchy. Lexical analysis and syntax analysis: LL and LR parsers.

Syntax directed translation. Execution environments. Code generation.

References:

Stefani Crespi Reghizzi, "Linguaggi formali e artificiali, aspetti sintattici", Citta' Studi edizioni

A.V. Aho, R. Sethi e J.D. Ullman "Compilers Principles, Techniques, and Tools", Addison_wesley, 1986.

4) Database Systems and Information Systems

Data Models: High-level Conceptual Data Models for Database Design, Relational Data Model (Relational Algebra, Tuple Relational Calculus, Domain Relational Calculus and Visual Query Language, SQL).

Relational Normalization Theory.

Triggers and Active Databases.

Physical Data Organization and Indexing. Query Processing and Query Optimization.

Transaction Processing (Concurrency Control, System Crash and Recovery Procedures, Security Techniques).

Advanced Data Models: Object Oriented Databases and Object Relational Models, SQL1999, Distributed Databases.

Reference textbooks:

Thomas Connolly, Carolyn Begg: "Data Base Systems - A Practical Approach to Design, Implementation and Management", Addison Wesley, Fourth Edition, 2005.

[Database Systems: An Application Oriented Approach, Complete Version \(2nd Edition\)](#) by Michael Kifer, Arthur Bernstein, and Philip M. Lewis (Hardcover - Mar 16, 2005)

5) Ingegneria del software.

Definizione e problemi del processo software, attività di pianificazione, analisi dei requisiti, specifica di sistema e di dettaglio, progettazione funzionale, progettazione orientata agli oggetti, codifica, verifica e testing, le metriche del software.

Il testo di riferimento è Pankaj Jalote "An integrated approach to software engineering".

Altri testi di consultazione: Ian Sommerville "Software Engineering".

6) Artificial Intelligence

Automated problem solving (problem representation, solving problem by searching, heuristic search, problem decomposition, constraintsatisfaction, adversarial search)

Knowledge representation and logical formalisms

Knowledge representation and structured approaches (Semantics nets, frames, Description logics, ontologies)

Planning

Uncertain knowledge and reasoning

Machine learning

Intelligent agents

Reference textbook: Russel Norvig: "Artificial Intelligence: A modern approach" 2nd edition, Prentice Hall, Pearson Education, 2003

7) Programming languages and paradigms

Main concepts of programming languages: variables, expressions, data types, control structures, blocks and modules.

Control abstractions: procedures. Data abstractions: abstract data types.

Object oriented programming: objects, classes, inheritance, dynamic binding.

Functional and logic programming.

References:

- M. Gabbriellini e S. Martini "Linguaggi di programmazione: principi e paradigmi" McGraw-Hill Italia, 2006.
- C.S.Horstmann e G. Cornell "Core JAVA 2 Vol I – Fondamenti" Pearson Education Italia, 2005.

8) Computer Networks

Main concepts of computer networks:

1. Architecture of communication networks: Local Area Networks (wired and wireless), Wide Area Network, internetworking and the Internet
2. Physical Media
3. Application Layer protocols: HTTP, FTP, SMTP, DNS
4. Transport Layer techniques and protocols: multiplexing-demultiplexing, connectionless transport and UDP, connection-oriented transport and TCP, congestion control
5. Networking layer and routing
6. Link layer techniques and protocols: error detection and correction, Multiple Access Protocols, Ethernet, Wireless networks

Reference textbooks: J.F. Kurose, K.W. Ross. "Computer Networking: A Top-Down Approach Featuring the Internet, 3rd Ed., Addison Wesley, 2005