Graduate Program in Computational Science (GPCS)

Chairperson:	Nassif, Nabil (Mathematics, FAS)
Committee Members:	Abu Salem, Fatima (Computer Science, FAS)
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The practice of computational science combines domain expertise in mathematical modeling and computing disciplines as vital tools in solving fundamental and challenging application areas problems in science, engineering, finance, economics and recently new disciplines in health and medical sciences. The scope of the program curriculum includes fundamental material from computer science (sequential and parallel algorithms, networks), numerical and symbolic computing, discrete and continuous mathematics (logic, number theory, graphs, differential equations and Fourier analysis, optimization, statistics and data analysis...), scientific software environments (UNIX, C, MATLAB, MPI and OpenMP, statistical packages...). It also requires sufficient knowledge in at least one application area selected from the sciences (natural, social, engineering, health medical, management and finance).

The mission of the inter-disciplinary Master's program in computational science is to provide a sufficiently broad educational environment that qualifies its holders to design and implement computational models in at least one application area. The program offers two tracks: a Research Master's degree for students who intend to join a PhD program after their graduation and a Professional Master's degree.

Admission Requirements

Admission to the Master's program in computational science follows basic AUB regulations. Regular students should be either:

- Holders of a Bachelor's degree in biology, business, computer science, economics, engineering, chemistry, mathematics, physics and have successfully completed the equivalent of CMPS 200, MATH 201, MATH 202, MATH 218 or 219, sufficient maturity in discrete mathematics (at the level of MATH/CMPS 211), MATH/CMPS 251, STAT 230(233) or
- Holders of a Bachelor's degree having completed the equivalent of MATH 202, STAT 230 and the FAS core courses requirements for a minor in computational science.

Some candidates may be admitted on probation or as prospective students until full completion of the required undergraduate courses.

Graduate assistantships are available for some applicants to the program based on qualifications.

Graduation Requirements

- 9 credits of computational science courses: MATH/CMPS 350 (Discrete Models of Differential Equations), MATH/CMPS 351 (Optimization and Non-linear Problems), MATH/CMPS 358 (Introduction to Symbolic Computing)
- 12 approved credits from a list of well-specified courses in computer science (CMPS), computational science (MATH/CMPS), engineering science (CIVE, MECH), mathematics (MATH), natural sciences (PHYS, CHEM, BIOL), decision sciences (STAT, ECON, ENMG)
- A thesis where "candidates demonstrate ability of using computational science tools to design a computational model for a specific problem emanating from one application area."

Core Courses Offered in Computational Science

All computational science courses are cross-listed under mathematics and computer science departments (MATH/CMPS).

CMPS 350/ MATH 350 **Computational Methods for Differential Equations** **3.1; 3 cr.**

A detailed study of methods and tools used in deriving discrete algebraic systems of equations for ordinary and partial differential equations: finite difference and finite element discretization procedures; generation and decomposition of sparse matrices, finite-precision arithmetic, ill-conditioning and pre-conditioning, Scalar, vector and parallelized versions of the algorithms. The course includes tutorial "immersion" sessions in which students become acquainted with state-of-the-art scientific software tools on standard computational platforms. *Prerequisite: Equivalent of MATH 218 and STAT 230. Corequisite: MATH/CMPS 251 or consent of the instructor. Annually.*

MATH 351/ CMPS 351 **Optimization and Non-Linear Problems** **3.1; 3 cr.**

A study of practical methods for formulating and solving numerical optimization problems that arise in science, engineering, and business applications. Newton's method for nonlinear equations and unconstrained optimization. Simplex and interior-point methods for linear programming. Equality and inequality-constrained optimization. Sequential Quadratic Programming. Emphasis is on algorithmic description and analysis. The course includes an implementation component where students develop software and use state-of-the-art numerical libraries. *Prerequisite: MATH/CMPS 350 or consent of the instructor. Annually.*

MATH 358/ CMPS 358 **Introduction to Symbolic Computing** **3.0; 3 cr.**

Introductory topics in computer algebra and algorithmic number theory that includes Fast multiplication of polynomials and integers, Fast Fourier transforms, primality testing and integers factorization. Applications to cryptography and pseudo-random number generation. Linear algebra and polynomial factorization over finite fields. Applications to error-correcting codes. Introduction to Grobner bases. *Prerequisite: consent of the instructor. Annually.*

MATH 360/ CMPS 360 **Special Topics in Computational Science** **3.0; 3 cr.**

A course on selected topics in computational science, which change according to the interests of visiting faculty, instructors and students. Selected topics will cover state-of-the-art tools and applications in computational science. *Prerequisite: consent of the instructor. Annually.*