

# Computational Science

In the College of Sciences

**OFFICE: Geology/Mathematics/Computer Science 206H**  
**TELEPHONE: 619-594-3430 / FAX: 619-594-2459**  
<http://www.csrc.sdsu.edu>

## Associated Faculty for Computational Science

José E. Castillo, Ph.D., Professor of Mathematics, Program Director  
Peter V. Blomgren, Ph.D., Professor of Mathematics  
Ricardo Carretero, Ph.D., Professor of Mathematics  
Andrew L. Cooksy, Ph.D., Professor of Chemistry and Biochemistry  
Robert A. Edwards, Ph.D., Professor of Computer Science  
Juanjuan Fan, Ph.D., Professor of Statistics  
Gustaaf B. Jacobs, Ph.D., Professor of Aerospace Engineering  
Calvin W. Johnson, Ph.D., Professor of Physics  
Sunil Kumar, Ph.D., Professor of Electrical and Computer Engineering  
Richard A. Levine, Ph.D., Professor of Statistics  
Ralph-Axel Müller, Ph.D., Professor of Psychology  
Antonio Palacios, Ph.D., Professor of Mathematics  
Paolini, Paul J., Jr., Ph.D., Professor of Biology  
Forest L. Rohwer, Ph.D., Professor of Biology  
Eric L. Sandquist, Ph.D., Professor of Astronomy  
Anca Mara Segall, Ph.D., Professor of Biology  
Satish Kumar Sharma, Ph.D., Professor of Electrical and Computer Engineering  
Samuel S.P. Shen, Ph.D., Albert W. Johnson Distinguished, Professor of Mathematics  
Satchi Venkataraman, Ph.D., Professor of Aerospace Engineering  
Fridolin Weber, Ph.D., Albert W. Johnson Distinguished Professor of Physics  
Tao Xie, Ph.D., Professor of Computer Science  
Robert W. Zeller, Ph.D., Professor of Biology  
Ashkan Ashrafi, Ph.D., Associate Professor of Electrical and Computer Engineering  
Barbara Ann Bailey, Ph.D., Associate Professor of Statistics  
Arlette R.C. Baljon, Ph.D., Associate Professor of Physics  
Luciano Demasi, Ph.D., Associate Professor of Aerospace Engineering  
Bo-Wen Shen, Ph.D., Associate Professor of Mathematics  
Christopher W. Curtis, Ph.D., Assistant Professor of Mathematics  
Jerome E. Gilles, Ph.D., Assistant Professor of Mathematics  
Ke Huang, Ph.D., Assistant Professor of Electrical and Computer Engineering  
Parag Katira, Ph.D., Assistant Professor of Mechanical Engineering  
Lyuba Pavlovna Kuznetsova, Ph.D., Assistant Professor of Physics  
Xiaobai Liu, Ph.D., Assistant Professor of Computer Science  
Antoni Luque, Ph.D., Assistant Professor of Mathematics  
Huu Ngoc Duy Nguyen, Ph.D., Assistant Professor of Electrical and Computer Engineering  
Wei Wang, Ph.D., Assistant Professor of Computer Science

## Admission to Graduate Study

Students applying for admission should electronically submit the university application available at <http://www.calstate.edu/apply> along with the \$55 application fee.

All applicants must submit admissions materials separately to SDSU Graduate Admissions and to Computational Science.

### Graduate Admissions

The following materials should be submitted as a complete package directly to:

Graduate Admissions  
Enrollment Services  
San Diego State University  
San Diego, CA 92182-7416

- (1) Official transcripts (in sealed envelopes) from all post-secondary institutions attended;

#### NOTE:

- Students who attended SDSU need only submit transcripts for work completed since last attendance.
- Students with international coursework must submit both the official transcript and proof of degree. If documents are in a language other than English, they must be accompanied by a certified English translation.

- (2) GRE scores (<http://www.ets.org> SDSU institution code 4682);

- (3) English language score, if medium of instruction was in a language other than English (<http://www.ets.org> SDSU institution code 4682).

### Master of Science Degree in Computational Science

The following materials should be submitted electronically to the Computational Science Research Center at San Diego State University. Refer to the Graduate Admissions website (<http://arweb.sdsu.edu/es/admissions/grad/programs/index.html>) for application instructions. Consult the department website ([http://www.csrc.sdsu.edu/masters\\_checklist.html](http://www.csrc.sdsu.edu/masters_checklist.html)) for details concerning required materials.

- (1) Three letters of recommendation from persons in a position to judge academic ability;
- (2) Personal statement of motivating interest for the program and briefly describe research interests and educational goals.

### Ph.D. Degree in Computational Science

The following materials should be submitted electronically to the Computational Science Research Center at San Diego State University. Refer to the Graduate Admissions website (<http://arweb.sdsu.edu/es/admissions/grad/programs/index.html>) for application instructions. Consult the department website ([http://www.csrc.sdsu.edu/masters\\_checklist.html](http://www.csrc.sdsu.edu/masters_checklist.html)) for details concerning required materials.

- (1) Three letters of recommendation from former or current professors, supervisors, or other appropriate persons;
- (2) Applicant's statement of purpose, explaining their interest in the program;
- (3) Claremont Graduate University application form;
- (4) Joint doctoral program in computational science application form;
- (5) Copies of unofficial transcripts from all post-secondary institutions attended.

## Section I. Master's Degree Programs

### General Information

The computational science program offers a Master of Science degree. It is offered in collaboration with the Departments of Biology, Chemistry and Biochemistry, Computer Science, Geological Sciences, Mathematics and Statistics, and Physics, in the College of Sciences.

Graduates of this program will have a solid foundation in a field of science and the additional training and experience required of computational science professionals. Fundamental science, in one of the specializations, dominates the program. This is supplemented with additional courses in computational science. Real scientific problem-solving is emphasized, through a thesis that could be done in conjunction with a carefully managed extramural research program. A significant proportion of the students in this program will be employed in positions related to their area of studies, thereby providing opportunities for extramural support. Graduates will be prepared for positions in scientific research, scientific programming, and software engineering.

### Associateships

Graduate teaching associateships and graduate nonteaching associateships may be available from the individual departments. See the appropriate department of this bulletin for more information.

### Admission to the Degree Curriculum

All students must satisfy the general requirements for admission to the university with classified graduate standing, as described in Part Two of this bulletin. If the undergraduate preparation of the students in the desired specialization is deficient, they will be required to take courses for the removal of the deficiency. These courses, taken by students as a classified graduate student, are in addition to the minimum 30 units required for the master's degree. A complete student program must be approved by the computational science program director. The requirements for entering this program consist of one year of computer programming (e.g., C or Fortran), competence in linear algebra and calculus, and a background equivalent to a bachelor's degree in the area of interest.

### Advancement to Candidacy

All students must satisfy the general requirements for advancement to candidacy as described in Part Four of this bulletin.

### Specific Requirements for the Master of Science Degree

**(Major Code: 07992) (SIMS Code: 773001)**

In addition to meeting the requirements for classified graduate standing, the student must satisfy the basic requirements for the master's degree as described in Part Four of this bulletin. The student must also complete a graduate program of 30 units, of which at least 15 units must be in 600- and 700-level courses excluding 799A to include:

#### Required core courses (21 units):

##### Core Courses

- COMP 521 Introduction to Computational Science (3)  
*OR* MATH 542 Introduction to Computational Ordinary of Differential Equations (3)
- COMP 526 Computational Methods for Scientists (3)  
*OR* MATH 693A Advanced Numerical Methods: Computational Optimization (3)
- COMP 536 Computational Modeling for Scientists (3)  
*OR* MATH 636 Mathematical Modeling (3)
- COMP 589 Computational Imaging (3)  
*OR* CS 559 Computer Vision (3)  
*OR* E E 657 Digital Image Processing (3)
- COMP 605/CS 605 Scientific Computing (3)
- COMP 626 Applied Mathematics for Computational Scientists (3)  
*OR* MATH 693B Advanced Numerical Methods: Computational Partial Differential Equations
- COMP 670 Seminar: Problems in Computational Science (3)

#### Elective courses (3 units selected from):

- STAT 670A Advanced Mathematical Statistics (3)
- CS 503 Scientific Database Techniques (3)

With consent of the program director, 600-level courses from other departments can be taken based on the student's background and research interest.

#### Project (3 units):

- COMP 799A Thesis (3) Cr/NC/RP

#### Research (3 units):

- COMP 797 Research (3) Cr/NC/RP

Substitution of core courses is permitted based on disciplines related to student's specialization with consent of director.

A complete student program must be approved by the computational science program director. The requirements for entering this program consists of one year of computer programming in a programming language such as C or Fortran, competence in linear algebra and calculus, with background equivalent to a bachelor's degree in the area of interest.

### Concentration in Professional Applications (Offered through the College of Extended Studies) (Major Code: 07992) (SIMS Code: 773010)

No students admitted to program at this time.

The concentration focuses on professional applications of computational science. To enter the program, students must possess a bachelors degree with a strong mathematical background. The student must complete a graduate program of 40 units to include the following:

#### Required core courses (34 units):

##### Core Courses

- COMP 526 Computational Methods for Scientists (3)
- COMP 536 Computational Modeling for Scientists (3)
- COMP 589 Computational Imaging (3)
- COMP 602 Organizational Development (2)
- COMP 626 Applied Mathematics for Computational Scientists (3)
- COMP 670 Seminar: Problems in Computational Science (3)
- COMP 671 Problem Solving Techniques (3)

#### Electives (14 units with consent of program director)

##### Project (6 units):

- COMP 797 Research (3) Cr/NC/RP
- COMP 798 Special Study (3) and comprehensive examination

Substitution of core courses is permitted based on disciplines related to student's specialization with consent of director.

## Section II. Doctoral Program

<http://www.csrc.sdsu.edu/doctoral.html>

### General Information

San Diego State University and Claremont Graduate University, offer jointly a doctoral program in computational science and a concentration in statistics. The cooperating faculties are from the Colleges of Engineering and Sciences at San Diego State University and participating units from Claremont Graduate University.

### Admission to the Degree Curriculum

In order to be considered for admission into the program, applicants must fulfill the general requirements for admission with graduate standing to both institutions. Applicants must meet special requirements of this program which include (a) a baccalaureate degree from an accredited institution in a scientific discipline or engineering.

Applications from outstanding candidates with degrees in other areas may be accepted conditionally; normally, these students will be expected to take during their first year of enrollment the necessary coursework to eliminate deficiencies; (b) an undergraduate minimum grade point average of 3.0 and minimum 3.50 in any previous graduate coursework; (c) suitable scores on both the quantitative and verbal sections of the Graduate Record Examination.

**Faculty Advisers and Doctoral Committee:** Upon admission to the program, the student will be assigned a faculty mentor from either institution. After completing the first year of study and receiving a progress evaluation, the student will select a doctoral adviser. The doctoral adviser will aide in the development of a suitable course of study for the student, administer the student's qualifying examination, monitor progress of student research and administer the defense of the doctoral dissertation.

## Specific Requirements for the Doctor of Philosophy Degree

**(Major Code: 07992) (SIMS Code: 773002)**

The program consists of a minimum of 72 units of coursework, independent study, and research (including transfer credit) distributed as follows. Any deviation from the program of studies must be done with the approval of the program director.

Minimum 24 units of graduate level coursework at SDSU (computational science program);

Minimum 24 units of graduate level coursework at CGU (graduate mathematics program);

Minimum 24 units of research, practicum, dissertation, and graduate seminar at either institution.

An additional 24 to 48 units of research, practicum, dissertation, and graduate seminar (COMP 800) may be taken at either institution. A student entering the program with a Bachelor of Science degree will satisfy the initial 24 unit requirement by completing a Master of Science degree in computational science at SDSU, then take 24 units of coursework at CGU. Students with an advanced degree other than computational science will complete appropriate courses and a research project to obtain the equivalent of an M.S. degree in computational science.

**Claremont Graduate University Courses:** Students are required to take 24 units at Claremont Graduate University. There is a core course requirement that must be satisfied with students selecting at least one course each from three of the following four categories:

**Category 1:** Mathematics 389, Discrete Modeling.

**Category 2:** Advanced Statistics with Computation: Examples of courses that would fulfill this requirement include Mathematics 351, Time Series; Mathematics 352, Nonparametric Statistics with Resampling Methods; Mathematics 353, Advanced Topics in Statistics Inference; Mathematics 355, Linear Statistical Models.

**Category 3:** Mathematics 368, Advanced Numerical Analysis or Mathematics 362, Numerical PDEs.

**Category 4:** Exotic Algorithms: Mathematics 469, Artificial Neural Networks; Mathematics 359 or 369, Monte Carlo Methods.

The additional units taken to make up the 24 unit requirement at Claremont Graduate University are electives to be selected with approval of the faculty adviser at SDSU and CGU. For example, students interested in computational problems in finance may elect to take Mathematics 358, Mathematical Finance, or other related electives. Students whose computational interests lie in signal processing and encryption may take Mathematics 335, Integral Transforms; Mathematics 374, Encoding and Encryption; and/or Mathematics 350, Kalman Filtering. The student's program of study beyond the core requirement will be tailored to the student's individual research interests.

**Research Units at SDSU:** Computational Science 800, 810, 894, 896, 897, 898, 899.

**Qualifying Examination.** The qualifying examination shall consist of a term research project supervised by a faculty mentor. The topic of the project will be approved by the program directors in consultation with the faculty mentor. The student will be required to prepare a written

account of the research work performed and of its results, and offer an oral presentation before the members of the advisory committee. This level of evaluation will be equivalent and coincide with the computational science Master of Science degree final examination.

**Practicum and Doctoral Research.** Dissertation research will be carried out here at one of the two institutions, at an industry, or at a national laboratory. In the latter two cases, its denomination is practicum.

**Dissertation Proposal.** The dissertation proposal shall be submitted by the student to the advisory committee no later than upon completion of the student's third academic year in the program. The dissertation proposal will take the form of a scientific grant proposal to a major funding agency. The proposal will describe the research project that the student intends to carry out, on which the doctoral dissertation will be based. The student will also be required to deliver an oral presentation before the computational science faculty. Upon successful completion of the presentation, the student will be recommended for advancement to candidacy for the doctoral degree.

**Doctoral Dissertation.** Upon completion of the dissertation research, the candidate will submit the dissertation to the advisory committee. The candidate will also present a public oral defense of the dissertation. Before the presentation, an account of the work performed will be submitted for publication to a peer-reviewed, international research journal. Upon successful completion of the presentation, the candidate's advisory committee will make a recommendation to the graduate deans.

## Faculty

The following faculty members of the cooperating institutions participate in the joint doctoral program and are available for direction of research and as members of joint doctoral committees.

### San Diego State University

Program Director: José E. Castillo

Committee Members: Baljon, Beyene, Bhattacharjee, Blomgren, Bromley, Carretero, Castillo, Cooksy, Day, Edwards, Fargion, In, Johnson, Kevorkian, Kumar, Love, Mahaffy, McGuire, Mellors, Olevsky, Oseroff, O'Sullivan, Palacios, Paolini, Pullman, Roch, Rohwer, Salamon, Sandquist, Segall, Venkataraman, Waheed, Weber

### Claremont Graduate University

Program Director: John Angus

Committee Members: Angus, Cumberbatch, Dewey, Landsberg, Nadim, dePillis, Liebesking-Hadas, Raval, Spanier, Wild, Williamson

## Concentration in Statistics (Major Code: 07992) (SIMS Code: 773003)

Completion of the following coursework before entering the concentration: two semesters of mathematical statistics (at the level of Statistics 670A-670B), one semester of regression analysis (at the level of Statistics 510), and one semester of linear algebra (at the level of Mathematics 524), and a working knowledge of a programming language.

The program consists of a minimum of 72 units of coursework, independent study, and research distributed as follows. Any deviation from the program of studies must be done with the approval of the program director.

### SDSU courses:

1. Statistics 700, 701, 702.
2. Minimum 15 units of graduate level computational statistics coursework tailored to the student's research interests selected in consultation with and approved by program director.

### Claremont Graduate University courses:

1. Sixteen units from MATH 350, 351, 352, 353, 355, or computational statistics courses selected in consultation with and approved by program director.
2. Eight units of electives selected in consultation with and approved by program director.

### Minimum 24 units of research, practicum, dissertation, and graduate seminar at either institution:

Research units at SDSU: COMP 800, 894, 897, 898, 899.  
Research units at CGU: MATH 495, 498, 499.

A student with a Bachelor of Science degree will satisfy the initial 24 units of SDSU course requirements by completing a Master of Science degree in statistics at SDSU, with program of study to include Statistics 700, 701, and 702, then taking 24 units of coursework at CGU.

### Faculty

The following faculty members of the cooperating institutions are available for direction of research in the statistics concentration.

#### San Diego State University

Program Directors: José E. Castillo and Richard A. Levine

Doctoral advisers: Bailey, Chen, Duncan, Fan, Levine, Lin, Lui

#### Claremont Graduate University

Program Director: John Angus

Doctoral advisers: Angus, Hardin, Martinosi, Myhre, Raval, Schellhorn

### Associateships

Graduate teaching associateships in statistics and biostatistics are available and are awarded on a competitive basis by the Department of Mathematics and Statistics. Application forms and additional information may be secured from the office of the Department of Mathematics and Statistics.

## Advanced Certificate in Professional Computational Science

(Offered through the College of Extended Studies)

(SIMS Code: 773005)

The Advanced Certificate in Professional Computational Science is designed for private and public industry professionals as well as graduate students who wish to learn professional and technical computational skills in their fields to include tools available for scientific application development (particularly those targeted as parallel and distributed systems), scientific visualization and database query applications, simulation and modeling packages, computational templates such as Matlab and Maple, and the choice of appropriate hardware resources for different classes of computational problems. Credit earned through the Advanced Certificate in Professional Computational Science can be applied toward the units required to obtain the Master of Science degree in Computational Science with a Concentration in Professional Applications.

The advanced certificate requires 12 units to include Computational Science 526, 589, and six additional units with consent of the program director. Each course must be completed with a grade of B (3.0) or better.

## Courses Acceptable for Master's and Doctoral Degree Programs in Computational Science (COMP)

Refer to *Courses and Curricula and Regulations of the Division of Graduate Affairs* sections of this bulletin for explanation of the course numbering system, unit or credit hour, prerequisites, and related information.

### UPPER DIVISION COURSES

#### COMP 521. Introduction to Computational Science (3)

Prerequisite: Mathematics 151.

Matrices and linear equations, solving ordinary differential equations (ODEs), vector spaces, closed form solutions, qualitative theory, Eigenvalues, linear maps, linear differential equations, other techniques, nonlinear systems, higher dimensional systems.

#### COMP 526. Computational Methods for Scientists (3)

Prerequisites: Mathematics 252 and 254.

Translating mathematical problem descriptions to computer programs. Introduction to Unix system.

#### COMP 536. Computational Modeling for Scientists (3)

Prerequisite: Mathematics 151.

Models, computational tools, errors, system dynamics, growth, stability, multicompartment models, Euler's, Runge-Kutta methods, system dynamics, infectious disease, enzyme kinetics, environmental cycles, cardiovascular system, metabolism, global warming, empirical models, HIV, population distributions, diffusion, HPC.

#### COMP 596. Advanced Topics in Computational Science (1-4)

Prerequisite: Consent of instructor.

Selected topics in computational science. may be repeated with the approval of the instructor. See *Class Schedule* for specific content. Limit of nine units of any combination of 296, 496, 596 courses applicable to a bachelor's degree. Maximum credit of six units of 596 applicable to a bachelor's degree. Credit for 596 and 696 applicable to a master's degree with approval of the graduate adviser.

### GRADUATE COURSES

#### COMP 602. Organizational Development (2)

Prerequisite: Graduate standing.

Contemporary organizational and leadership theory and practice through personal reflection, team assessment and feedback, and case analysis. Nature of change, forces for change, and impact of change in organizations and individuals. Organizational processes, structures and cultures, and effect on organization's performance.

#### COMP 605. Scientific Computing (3)

(Same course as Computer Science 605)

Prerequisites: Graduate standing and knowledge of the C programming language or FORTRAN or Computational Science 526.

Parallel programming using message passing to include high performance computing and MPI language extensions.

#### COMP 626. Applied Mathematics for Computational Scientists (3)

Prerequisites: Mathematics 252 and 254.

Linear algebra, differential equations and stability theory, and analytical methods for partial differential equations within the context of computational science.

#### COMP 670. Seminar: Problems in Computational Science (3)

Prerequisite: Graduate standing.

Applications of computational science in solving problems using a variety of methods. Problems selected from biology, chemistry, physics, and other fields.

#### COMP 671. Problem Solving Techniques (3)

Prerequisite: Graduate standing.

Data abstraction and problem solving skills.

#### COMP 696. Selected Topics in Computational Science (3)

Prerequisite: Graduate standing.

Intensive study in specific areas of computational science. May be repeated with new content. See *Class Schedule* for specific content. Credit for 596 and 696 applicable to a master's degree with approval of the graduate adviser.

#### COMP 705. Advanced Parallel Computing (3)

(Same course as Computer Science 705)

Prerequisite: Computational Science 605 [or Computer Science 605].

Libraries, numerical methodology, optimization tools, visualization of results, MPI and GPU computing models. Applications conducted on CSRC student cluster and NSF XSEDE computing resources.

#### COMP 797. Research (1-3) Cr/NC/RP

Prerequisite: Six units of graduate level computational science courses.

Research in computational science. Maximum credit six units applicable to a master's degree.

#### COMP 798. Special Study (1-3) Cr/NC/RP

Prerequisite: Consent of staff; to be arranged with program director and instructor.

Individual study. Maximum credit six units applicable to a master's degree.

**COMP 799A. Thesis or Project (3) Cr/NC/RP**

Prerequisites: An officially appointed thesis committee and advancement to candidacy.

Preparation of a project or thesis for the master's degree.

**COMP 799B. Thesis or Project Extension (0) Cr/NC**

Prerequisite: Prior registration in Thesis or Project 799A with an assigned grade symbol of RP.

Registration required in any semester or term following assignment of RP in Course 799A in which the student expects to use the facilities and resources of the university; also student must be registered in the course when the completed thesis or project is granted final approval.

**COMP 799C. Comprehensive Examination Extension (0) Cr/NC**

Prerequisite: Completion or concurrent enrollment in degree program courses.

Registration required of students whose only requirement is completion of the comprehensive examination for the master's degree. Registration in 799C limited to two semesters.

**DOCTORAL COURSES**

**COMP 800. Seminar (3) Cr/NC/RP**

Prerequisite: Admission to the doctoral program.

Topics in different areas of computational science.

**COMP 810. Colloquium in Computational Science (1) Cr/NC/RP**

Prerequisite: Admission to the doctoral program.

Discussions on advances in computational science research. Course to be taken every semester.

**COMP 894. Supervised Research, Qualifying Examination, and Dissertation Proposal (3-9) Cr/NC/RP**

Prerequisites: Admission to the doctoral program and consent of instructor.

Research and preparation for qualifying examination.

**COMP 896. Practicum (1-9) Cr/NC/RP**

Prerequisite: Admission to the doctoral program.

Independent investigation in general area of field of dissertation. Conducted in industry or national laboratory under faculty supervision. Maximum credit 36 units.

**COMP 897. Doctoral Research (1-9) Cr/NC/RP**

Prerequisite: Admission to the doctoral program.

Independent investigation in general field of dissertation. Maximum credit 36 units.

**COMP 898. Doctoral Special Study (1-3) Cr/NC/RP**

Prerequisite: Advancement to candidacy.

Individual study leading to study and research required for doctoral dissertation.

**COMP 899. Doctoral Dissertation (1-15) Cr/NC/RP**

Prerequisite: An officially constituted dissertation committee and advancement to candidacy.

Preparation of the dissertation for the doctoral degree. Enrollment is required during the term in which the student plans to graduate.

