Computational Science
In the College of Sciences

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The Rollin and Caroline Eckis Chair in Seismology
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Scott T. Kelley, Ph.D., Professor of Biology
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Peter Salamon, Ph.D., Professor of Mathematics
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Robert W. Zeller, Ph.D., Professor of Biology

Admission to Graduate Study
Students applying for admission should electronically submit the university application available at http://www.csumentor.edu 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 mailed or delivered to:
Computational Science Research Center (Attention: Graduate Adviser)
San Diego State University
5500 Campanile Drive
San Diego, CA 92182-1245

(1) Three letters of recommendation (in sealed and signed envelopes) 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 mailed or delivered to:
Computational Science Research Center (Attention: Graduate Adviser)
San Diego State University
5500 Campanile Drive
San Diego, CA 92182-1245

(1) Three letters of recommendation (in sealed and signed envelopes) 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 available at http://www.csrc.sdsu.edu;
(4) Joint doctoral program in computational science application form available at http://www.csrc.sdsu.edu;
(5) Copies of official 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 (18 units):

<table>
<thead>
<tr>
<th>Course #</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>COMP 526</td>
<td>Computational Methods for Scientists (3)</td>
</tr>
<tr>
<td>OR MATH 693A Advanced Numerical Methods: Computational Optimization (3)</td>
<td></td>
</tr>
<tr>
<td>COMP 536</td>
<td>Computational Modeling for Scientists (3)</td>
</tr>
<tr>
<td>OR MATH 636 Mathematical Modeling (3)</td>
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</tr>
<tr>
<td>COMP 589</td>
<td>Computational Imaging (3)</td>
</tr>
<tr>
<td>OR CS 559 Computer Vision (3)</td>
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<tr>
<td>OR EE 657 Digital Image Processing (3)</td>
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</tr>
<tr>
<td>COMP 605/CS 605 Scientific Computing (3)</td>
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<tr>
<td>COMP 626</td>
<td>Applied Mathematics for Computational Scientists (3)</td>
</tr>
<tr>
<td>OR MATH 693B Advanced Numerical Methods: Computational Partial Differential Equations</td>
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<tr>
<td>COMP 670</td>
<td>Seminar: Problems in Computational Science (3)</td>
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</table>

Elective courses (9 units):

<table>
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<tr>
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<tbody>
<tr>
<td>COMP 521</td>
<td>Introduction to Computational Science (3) OR MATH 542 Introduction to Computational Ordinary Differential Equations (3)</td>
</tr>
<tr>
<td>COMP 604</td>
<td>Computational and Applied Statistics (3) OR STAT 670A Advanced Mathematical Statistics (3)</td>
</tr>
<tr>
<td>COMP 607</td>
<td>Computational Database Fundamentals (3) OR CS 503 Scientific Database Techniques (3)</td>
</tr>
</tbody>
</table>

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

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)
The concentration focuses on professional applications of computational science. To enter the program, students must possess a bachelor's 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):

<table>
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<tr>
<td>COMP 526</td>
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<tr>
<td>COMP 589</td>
<td>Computational Imaging (3)</td>
</tr>
<tr>
<td>COMP 601</td>
<td>Seminar: Business Skills for the Information Age (3)</td>
</tr>
<tr>
<td>COMP 602</td>
<td>Organizational Development (2)</td>
</tr>
<tr>
<td>COMP 603</td>
<td>Engineering Economics for Scientists (2)</td>
</tr>
<tr>
<td>COMP 604</td>
<td>Computational and Applied Statistics (3)</td>
</tr>
<tr>
<td>COMP 606</td>
<td>Designing Scientific and Industrial Experiments (3)</td>
</tr>
<tr>
<td>COMP 607</td>
<td>Computational Database Fundamentals (3)</td>
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<td>COMP 670</td>
<td>Seminar: Problems in Computational Science (3)</td>
</tr>
<tr>
<td>COMP 671</td>
<td>Problem Solving Techniques (3)</td>
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</tbody>
</table>

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/csrc/programs/phd.php

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 aid 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

Claremont Graduate University

Program Director: John Angus
Committee Members: Angus, Cumberbatch, Dewey, Landsberg, Nadim, dePillis, Liebeskind-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:
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.
Computational Science

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, Liu
Claremont Graduate University
Program Director: John Angus
Doctoral advisers: Angus, Hardin, Martino, 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)
(Certificate Code: 90046) (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, 601, 604 with a grade of B or better in each course. Other courses may not be substituted.

Courses Acceptable on 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 528. 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, multicomponent 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 589. Computational Imaging (3)
Prerequisites: Mathematics 150 and 254.
Mathematical techniques used for image processing and analysis.
Emphasis on variational techniques which lead to PDE based image processing algorithms, most are known as diffusion filters, and interface propagation techniques for which emphasis will be implicit representation (level-set methods). Representation and properties of curves and surfaces, statistical (PCA/ICA), and multi-resolution image analysis techniques.

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 596, 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 601. Seminar: Business Skills for the Information Age (3)
Prerequisite: Graduate standing.
Human and infrastructure management issues specific to science and technology workplaces.

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 603. Engineering Economics for Scientists (2)
Prerequisites: MS Excel and basic mathematics.
Systematic economic analysis of engineering problems.

COMP 604. Computational and Applied Statistics (3)
Prerequisite: Mathematics 254.
Statistical decision making and methods relevant to scientific inquiries.

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 606. Designing Scientific and Industrial Experiments (3)
Prerequisite: Computational Science 604.
Design selection, data collection, and evaluation using multiple regression to analyze experimental data.

COMP 607. Computational Database Fundamentals (3)
Prerequisite: Graduate standing.
Data-processing techniques, software, database design, implementation, and manipulation.

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 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)
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. (Formerly numbered Computational Science 890 and 895.)

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
Prerequisites: 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.