Why should you study Computational Science?

- To use computers to solve significant and complex problems
- To acquire unique skills that are highly sought by employers
- To prepare for graduate study in the physical, life, behavioral and social sciences

What exactly is Computational Science?

Computational Science is the emerging and rapidly growing interdisciplinary field in which researchers use computer modeling and simulation to solve complex business, technical and academic problems. Businesses recognize computational science as an essential tool for innovation and use it to develop new products. Researchers do the same to expand the frontiers of knowledge. Computational science has produced enormous advances in scientific and technological inquiry including DNA sequencing, behavioral modeling, global climatic predictions, drug design, financial systems and medical visualization.

What is the benefit of a Computational Science minor?

A minor in computational science will provide students who already have expertise in science and engineering with skills they can use to complete computationally based projects. Further, the competencies created by the participating faculty have been reviewed and approved by a business advisory committee, meaning that when you enter the workforce with this background, you will have the specific skills sought by employers.

What is the Ralph Regula School?

The Ralph Regula School of Computational Science is a statewide, virtual school focused on computational science, and specifically computer modeling and simulation. It is a collaborative effort of the Ohio Board of Regents, Ohio Supercomputer Center, Ohio Learning Network, and Ohio's colleges and universities.

The Ralph Regula School does not offer degrees or program certificates on its own – in all cases this will be handled by participating colleges and universities. Instead, the Ralph Regula School draws upon the resources and expertise of Ohio's colleges and universities to develop and offer coursework for academic programs and certificates.

Ralph Regula School of
Computational Science
an initiative of the Ohio Supercomputer Center

National Science Foundation, SCI-0537405

How does the curriculum work?

The final curriculum is being approved at several of the participating institutions, but will consist of the same core courses. To complete the minor, you must take five required courses and at least one elective course. The minor also requires you to complete a full year of calculus as part of your major.

No matter where the courses are taught, students at any of the participating institutions can register for any of the courses that are part of the minor program. You register and pay tuition at your home institution, but can take any of the courses – because most of them are taught as distance learning courses. The only difference is that courses run on the schedule of the teaching institution (quarter or semester), which might be different than the one at your university.

Participating Institutions
Capital University
Central State University
Columbus State Community College
Kent State University
Ohio University
Miami University
Owens Community College
Sinclair Community College
Stark State College
The Ohio State University
University of Cincinnati
Wittenberg University

How do I register or get more information?

A full list of the courses being offered in the current academic year is available on the Ralph Regula School Computational Science website at www.rrscs.org/minorcourses. The website shows the courses being offered, the offering institution and the schedule for the course at that institution. The website also lists the name of a program adviser at each campus who can provide you with information about the program and who can help you with registration.

If you find a course offered at your home institution, you simply go ahead and register for it in the normal way. If you wish to take a course at another institution, you need to fill out one or two extra forms. The Application for Host Institution Class Enrollment form can be found on the same website. Complete the form and turn it in to your registrar's office. That office will send the form to the host institution and register you for those credits at your home institution. You should then receive notification from the hosting institution that you are registered along with any other instructions you need to start the course.

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Ohio Supercomputer Center

Ohio Learning Network

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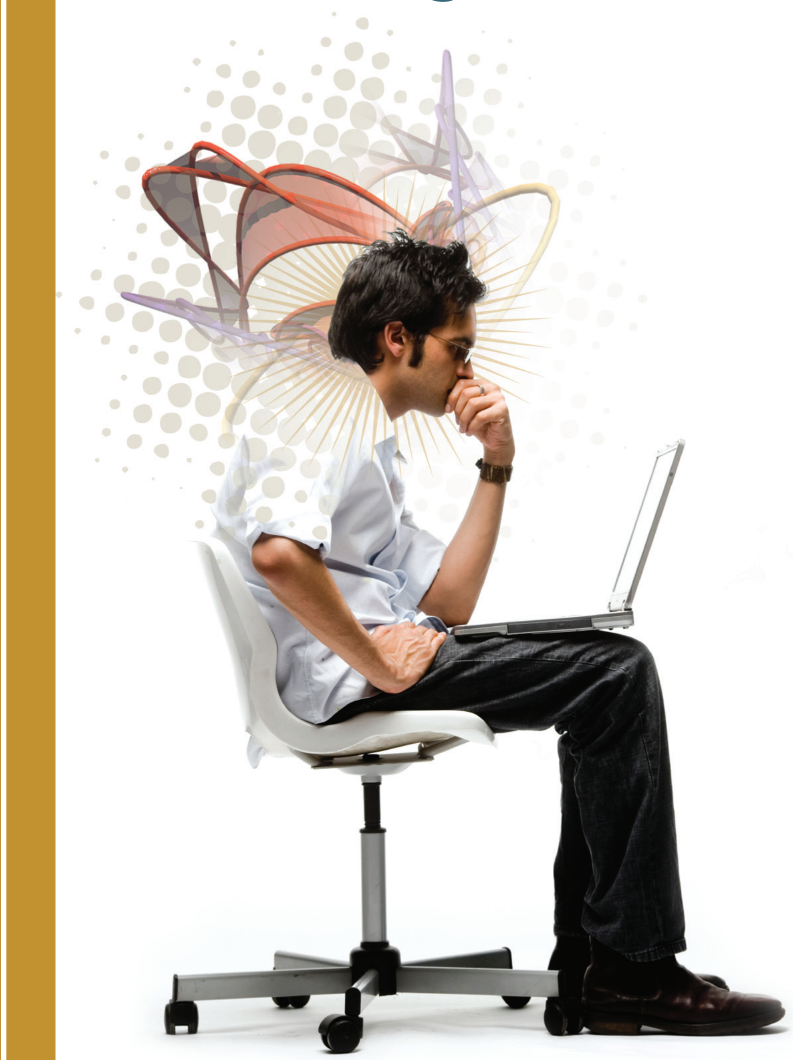
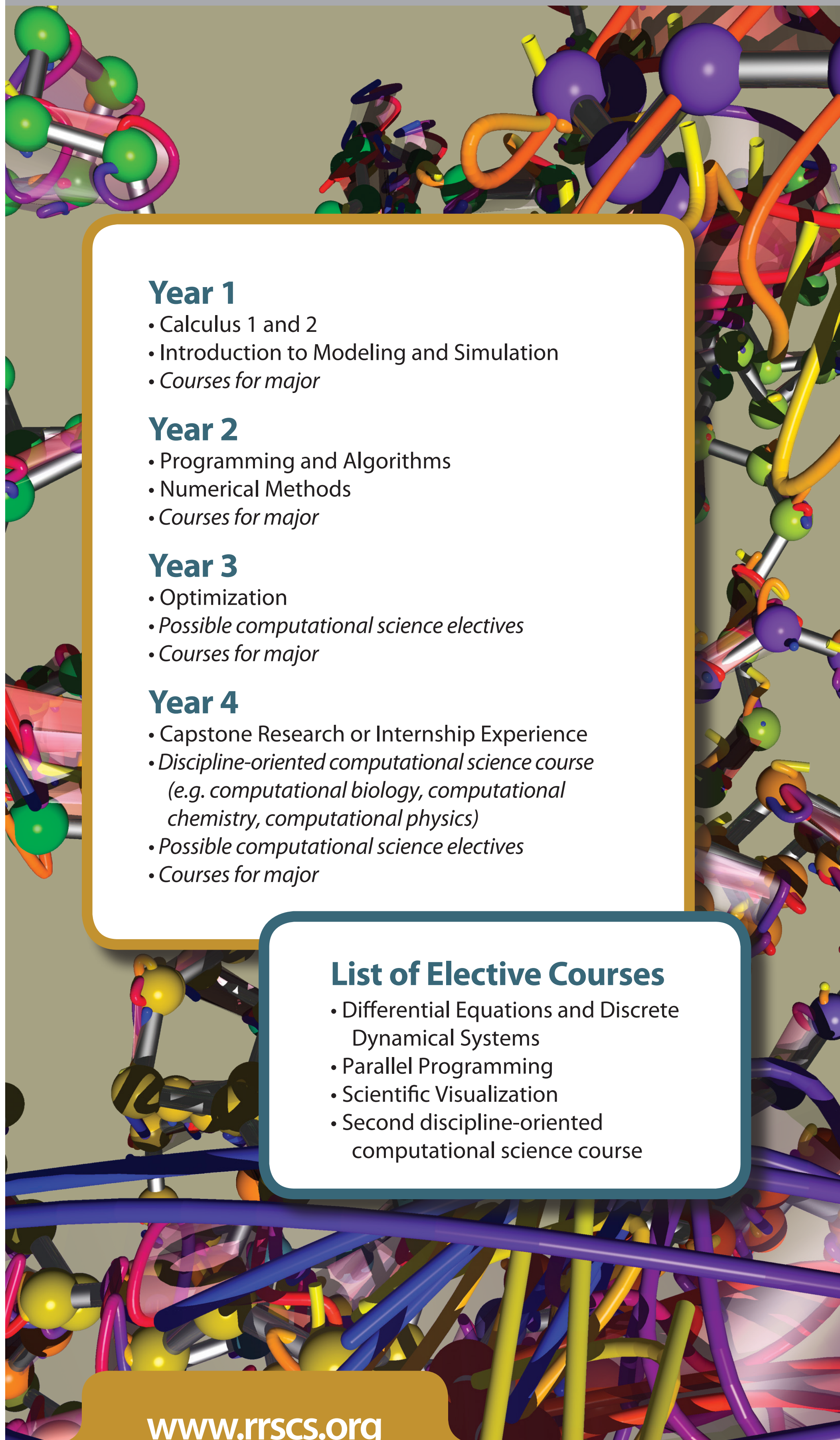
Minor Program



Ensuring that Ohio has the skilled people needed to support new approaches to innovation.

www.rrscs.org



Year 1
- Calculus 1 and 2
- Introduction to Modeling and Simulation
- *Courses for major*

Year 2
- Programming and Algorithms
- Numerical Methods
- *Courses for major*

Year 3
- Optimization
- *Possible computational science electives*
- *Courses for major*

Year 4
- Capstone Research or Internship Experience
- *Discipline-oriented computational science course (e.g. computational biology, computational chemistry, computational physics)*
- *Possible computational science electives*
- *Courses for major*

List of Elective Courses
- Differential Equations and Discrete Dynamical Systems
- Parallel Programming
- Scientific Visualization
- Second discipline-oriented computational science course

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What topics will be covered in the courses?

Simulation and Modeling
The first course in computational science will introduce you to computer modeling and how it is being used in business and academic research as a way to save time and money, develop new products and processes, and gain a fundamental understanding of how things work. You will learn how to construct a model, measure whether you are getting the "right" answer and use models to give you important insights. You will simulate phenomena like a skydiver jumping from a plane, the flow of traffic on a highway, the growth of population, the dynamics of predator and prey in an ecosystem and the spread of disease. You will learn to use tools to visualize your model results and to test different model assumptions while you learn about the mathematics that underlie the simulations.

Programming and Algorithms
This is an introductory course in programming and algorithms for students in computational science. You will learn the logic and design of procedural programs, floating point arithmetic, vectors, matrices, complex numbers, and elementary data structures. You will look more in-depth at how different algorithms can be used to improve the accuracy of computer models, as well as at the performance of those programs (how fast they run).

Computational Biology and Bioinformatics
The recent explosion of completely sequenced genomic sequences and other high-throughput -omics data provides scientists with an enormous wealth of biological information. Computational biology and bioinformatics, relatively new and rapidly expanding areas, are dedicated to the various ways that computers and computational techniques can be used to utilize this biological data. Because of a diversity of issues that go beyond data analysis, such as need for gathering data, storing, handling, and distributing, this discipline requires skills that come from different fields, including high-performance computing, development and application of novel algorithms and software tools, and scientific visualization. Bioinformatics offers you several essential skills, including database search and retrieval, sequence homology search and sequence alignments, introduction into phylogenetic analysis, analysis of gene expression, and protein structure prediction. A basic introduction into molecular biology concepts is included, making this course accessible to non-biology majors.

Computational Chemistry
This course will introduce you to applications and methodologies, such as molecular mechanics, density functional theory, semi-empirical and ab initio molecular orbital theory, as well as molecular dynamics for computational chemistry and biological applications. Computational Chemistry will expose you to the different theoretical methods and show you how (practically) to use different molecular mechanics and electronic structure programs to solve problems. The course will provide access to the necessary computational facilities and software.

Computational Physics
In this course, you will learn to apply computation to problems of interest to physics. This may involve numerical computation, symbolic calculations, visualization or a mix of these. Many of the most interesting problems in physics are too complicated for analytic solution and must be tackled numerically.

Differential Equations and Discrete Dynamical Systems
Using modeling, you will learn techniques for solving a variety of ordinary differential equations for both linear and non-linear systems. The numerical accuracy of different solutions will be examined. Examples will be drawn from other applied science and engineering areas.

Numerical Methods
You will use a variety of numerical methods to solve computational problems. These will include techniques for solving systems of linear equations, interpolation and approximation methods, and methods to solve ordinary differential equations and partial differential equations. You also will study Monte Carlo or random behavior methods and apply several algorithms to study physical phenomena that can be simulated using those techniques.

Optimization
You will learn the many circumstances in which models can be used to find the optimal solution to a problem – one that best achieves a particular objective. This course shows you how to apply optimization techniques to a variety of problems. Both linear and non-linear optimization methods will be covered.

Parallel Programming
Although computer processors have become extraordinarily fast, they are still not fast enough to solve the most challenging problems on a single processor in a reasonable amount of time. You will explore how parallel programming takes advantage of multiple processors working on the same problem at the same time in order to arrive at an answer more quickly. Parallel programming is being applied extensively to existing science and engineering problems. Multiple processors are even beginning to appear on standard desktop and laptop machines and will use the same principles to accelerate everyday calculation. This course introduces you to the principles of parallel programming and applies these principles to example problems from science and engineering. You will design, analyze, and run parallel programs and learn how to efficiently scale a program to run on many processors in parallel.

Internship or Research Experience
You will apply your knowledge of computational science in a research or internship experience with a faculty member or a private firm. The Ralph Regula School of Computational Science works with faculty and employers to list available positions and matches your interests with an appropriate experience. The experience will be invaluable as you seek employment after graduation.