THE UNIVERSITY OF TEXAS AT AUSTIN
Department of Statistics and Data Sciences
College of Natural Sciences

Certificate in Scientific Computation
Research Paper Process & Requirements

The final requirement for the *Certificate in Scientific Computation* program is an original research project that is presented in a research paper.

Steps in the Research Paper Process:

Before Registration in SDS 379R	1. Identify a research topic and potential faculty supervisor.
	2. Prepare a 1-2 page research proposal to discuss with faculty supervisor with 3 sections: Introduction, Methodology, and Faculty Mentor. (Clearly articulate how your proposed research relates to scientific computation and include a brief statement about the type of computation you will do (e.g. which computer programming language(s), enhance existing code and/or develop new program), in addition to why you chose your faculty mentor. What characteristics and expertise are important for your mentor to supervise your project.)
	3. Set meeting with faculty supervisor to discuss proposal.
	4. Complete the Research Contract with both student and faculty supervisor signing and dating the Research Contract.
	5. Submit signed Research Contract and Research Registration form to Vicki Keller no later than one week before the start of classes.
	6. The Faculty Steering Committee reviews the research proposal and makes recommendations to ensure project meets program requirements.
	7. SDS (Vicki) enrolls student in SDS 379R once proposal has been approved.
Student Enrolled in SDS 379R	
While Enrolled in SDS 379R	1. Work on research as planned
	2. Meet & communicate with faculty supervisor as agreed
	3. Submit drafts to faculty supervisor as planned
	4. Submit final draft, including faculty signed cover sheet to the SDS office by 5 PM on May 1 (spring), August 7 (summer), or November 30 (fall). SUBMISSION INSTRUCTIONS: email electronic copy of paper to Vicki and turn in hard copies of the signed cover sheet.
	5. Instructor assigns grade for SDS 379R.
	6. The Faculty Steering Committee reviews the final research project to ensure project meets program requirements.

Research Paper Requirements

Formatting Requirements:

Title Page: include title, "completed for the Certificate in Scientific Computation," date, name, degree program, supervising faculty's name, department and signature
Page length: between 10-15 pages
Margins: 1-inch margins on all four sides, left-justified
Font: 12-pt Times
Line Spacing: single space
Style: APA, CSE, Chicago (pick style used in your field)
Tables and Figures: Number all tables and figures and use these numbers to explicitly refer to such items. Include a descriptive caption for each.

Research Topic

The student and supervising faculty member jointly select the topic of the research project and paper. This topic should be sufficiently narrow and focused for this scholarly exercise. Prepare a one- to two-page research proposal for section 1 in the Certificate in Scientific Computation Research Contract.

Paper Organization

Provide a descriptive title for your paper. The paper should have an abstract followed by the body of the paper followed by a bibliography. The body of the paper should be divided into appropriately sections with descriptive titles:

- **Abstract**: What did you do in 300 words or less?
- **Introduction**: What is the problem?
    - Include a prediction
    - Include a conclusion
- **Materials and Methods**: How did you solve (or go about attempting to solve) the problem?
    - Explicitly state what mathematical and/computational methods were used
- **Results**: What did you find out? Include an interpretation.
- **Discussion**: What does it mean?
- **Acknowledgements**: Who helped you?
- **Literature Cited**: Whose work did you refer to?
- **Computer Code:** included as an **appendix** or a second document when the number of code lines is very large. The code can also be put, in addition to the thesis document or second submitted document, in github or similar repository.
- **Reflection**: On separate page, what did you learn by doing this project? What was your contribution to the project if it was a joint effort?

Evaluation Criteria

Your supervising faculty member will provide you with the evaluation criteria s/he requires in order to assign you a grade for the course.

For the certificate program, your paper will be evaluated by the Faculty Steering Committee on a pass/fail basis based on the following criteria:

- Content: completeness, accuracy, and originality
- Results and contribution
- Organization
- Demonstration of Computational Skills:
    - For projects with a programming component -
        - Code should be documented and included in the appendix of the paper (see Paper requirements section).
        - Describe at least one key function of a library, include discussion about what are the input and output data, and computations performed to concert input into output data.
        - For projects with substantial data cleanup, filtering or other data pre and post- processing, describe pipeline in detail. Include discussion about filtering parameters.
    - For projects with an analysis component -
        - Each of the analysis programs should be described in at least one paragraph in the Materials and Methods section of the paper. Include reference(s) for this program, the analysis performed, if program is downloaded and run locally or from a web server.
        - Logical overview of the analysis pipeline.
        - Quality control, pre- and post- processing.
        - Confidence in the accuracy of the program? Include when approach, control analysis to evaluate the authenticity of the programs and/or analysis system.
        - Compare two or more computer packages with similar functions. Discuss run-time, algorithm behavior, algorithm accuracy and/or use of disk and other computer resources.
        - Describe, overall logic of the algorithm and their computational complexity.

Examples of past projects

"Improving Code That Demonstrates a Proposed Theory on the Physics of a Larger Cell's Process of Mitosis" by a **BS in Physics** student.
The purpose of this project was to create a code written in the C programming language that calculates the total drag force on a centrosome over time due to an accumulation of vesicles on the expanding microtubes spread across the centrosome's surface.

"Parallelized DSMC Simulation of Hydrogen with State-to-State Rotational Energy Transfer" by a **BS in Aerospace Engineering** student.
This research has taken an existing code base and extended it to incorporate parallelism. This has allowed for the reduction of time taken to generate simulation data, as well as increasing the per-node computational efficiency of

the code when executed on a system with more than a single computation core or processor.

"Exploring Pattern Separation in the Granule Cell Layer of the Cerebellum" by **a BS in Neuroscience** student.
In order to understand the principles of pattern separation and its association with the unique connectivity of the cerebellum, a theoretical model is needed so that complete knowledge of the system can be analyzed. A two-layer model consisting of a mossy fiber input layer and a granule cell layer was developed in Matlab.

"Performance Analysis for Scaling up R Computation Using Hadoop" by a **BS in Computer Science** student.
The number of big data applications in the scientific domain is continuously increasing. R is a popular language among the scientific community and has extensive support for mathematical and statistical analysis. Hadoop has grown into a universally used tool for data manipulation. We test three ways of integrating these two tools.

"Modeling Coupled Photovoltaic Power Plants with Compressed Air Energy Storage in Texas" by a **BS in Mechanical Engineering** student.
I determine the performance and cost of two photovoltaic power plants coupled with compressed air energy storage located in Odessa and Ennis, Texas, where I vary the level share of baseload power that each plant sends to the electrical grid in Dallas. I use computed daily solar irradiance values from 1984 to 2007 to estimate how much electricity the plants would have produced. Through an iterative algorithm I compute the array size and energy storage capacity that would result in a system capacity factor of .0907, based on which is the capacity factor of the current US nuclear fleet.

"Evaluation of 3D Eigenface and Fisherface Recognition Algorithms on Cancer Patients with Facial Disfigurement" by a **BS in Biomedical Engineering** student.
This study aims to evaluate the performance of the 3D eigenface and fisherface recognition algorithms on an image set of patients with facial disfigurement due to surgical treatment for facial cancer as a first step in constructing a metric to quantify changes in facila morphology.