Syllabus

From CS 477/577 Computer Simulation & Modeling

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Instructor Information

<table>
<thead>
<tr>
<th>Name:</th>
<th>Jesse Johnson</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office:</td>
<td>417 Social Science</td>
</tr>
<tr>
<td>Telephone:</td>
<td>(406) 243-2356</td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:jesse.johnson@umontana.edu">jesse.johnson@umontana.edu</a></td>
</tr>
<tr>
<td>Web:</td>
<td>CAS Web Page (<a href="http://hs.umt.edu/cs/facultyAndStaff/default.php?s=Johnson">http://hs.umt.edu/cs/facultyAndStaff/default.php?s=Johnson</a>)</td>
</tr>
<tr>
<td>Office Hours:</td>
<td>MWF 11:00--12:00 (via Teams or by appointment)</td>
</tr>
</tbody>
</table>

Online Course Tools
As you have no doubt noticed, the course will make heavy use of this wiki.

Textbooks

Readings in this course will be drawn from multiple sources. The primary inspiration for most problems is the first textbook, which is now out of print and as a result free. The PDF of this text can be downloaded from the files section of the Teams space.

Primary Text 1

**Title:** An Introduction to Computer Simulation Methods Second Edition Applications to Physical Systems  
**Author:** Harvey Gould and Jan Tobochnik and Wolfgang Christian  
**Edition:** Third Edition  
**Publisher:** 2006 Addison Wesley Publishing Group  
**ISBN Number:** ISBN 0-8053-7758-1

Supplemental Text: A very concise overview of many modern topics

**Title:** The Nature of Mathematical Modeling  
**Author:** Neil Gershenfeld  
**Edition:** First Edition  
**Publisher:** 2000 Cambridge University Press  
**ISBN Number:** ISBN 0-521-57095-6

Supplemental Text: A definitive resource with delightfully snappy prose.

**Title:** Numerical Recipes: The Art of Scientific Computing  
**Author:** William H. Press, Saul A. Teukolsky, William T. Vetterling, and Brian P. Flannery  
**Edition:** Third Edition  
**Publisher:** Cambridge University Press  
**ISBN Number:** ISBN-10: 0521880688

Prerequisites

- Good understanding of symbolic differentiation and integration (Math 152, 153 [http://www.umt.edu/catalog/cas/mathematical_sciences.htm]), some experience with linear algebra (Math 221 [http://www.umt.edu/catalog/cas/mathematical_sciences.htm]).
- Understanding of at least one modern, structured programming language at the depth taught in courses such as CSCI 135 or CSCI 250 [http://www.umt.edu/catalog/cat/cas/compsci.html]. eg fluency with assignment, looping, conditional branching, array manipulation, and functions. Familiarity with data structures and objects to the extent you can use them, if not create them.
- College level science courses, in order of relevance: Physics, Geology, Chemistry, Biology.
- A willingness to commit about 15 hours a week to the course.

Course Topics
This semester, I'd like to cover the following topics:

- Methods of manipulating Python numpy arrays using examples from complexity: Game of Life, Diffusion Limited Aggregation.
- The Ising Model
- The Metropolis-Hastings algorithm or the basis of Markov Chain Monte Carlo (MCMC) methods.
- The motion of projectiles.
- Ordinary differential equations for 1, 2, and N degrees of freedom.
- Optimization with the simplex and BFGS algorithms.
- The three-body problem.
- The Susceptible, Infected, Recovered (SIR) model for disease propagation.
- The Kalman filter.
- Finite difference approximations to partial differential equations.
- Numerical method of lines.

There are a number of new features in this course that recognize the importance of machine learning to computer science. Broadly, these are the areas related to the sampling of probability distributions (Metropolis-Hastings), optimization techniques, and parameter estimation (with Kalman filtering and other approaches). All the same, the course remains true to its original intent - you will learn to create dynamical models using ordinary and partial differential equations. This will be done in Python, using numpy, an all important advance in numerical computing that makes arrays of numbers the primary datatype.

I reserve the right to modify the schedule to reflect the way the course is going with respect to completion of assignments.

**Course Objectives**

After taking this course, students will be able to;

- create a computer simulation of a set of observations based on the physical characteristics of the system.
- solve both ordinary and partial differential equations with computers.
- learn to view a wide variety of problems as being optimizations.
- display insight into the uncertainties in a system, and how they can be characterized.
- manipulate the fundamental data structures of numerical computing; matrices and vectors.
- visually represent and understand data sets coming from computer simulations.

**Meeting Times/Place**

**Time:** Tuesday and Thursday 9:00 - 10:20  
**Place:** Social Science room 362

**Final Exam Time and Place**

**Time:** Monday April 26, 8:00-10:00  
**Place:** Social Science room 362

I have read this schedule incorrectly so many times in the past that I am including a link [1](https://www.umt.edu/registrar/students/Finals%20Week%20Schedules.php).
Grading Policy

Grading Breakdown

Grades of A-F will be assigned based on a percentage of the total possible points earned. The break points are as follows.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>94-100</td>
</tr>
<tr>
<td>A-</td>
<td>90-93</td>
</tr>
<tr>
<td>B+</td>
<td>87-89</td>
</tr>
<tr>
<td>B</td>
<td>83-86</td>
</tr>
<tr>
<td>B-</td>
<td>80-82</td>
</tr>
<tr>
<td>C+</td>
<td>77-79</td>
</tr>
<tr>
<td>C</td>
<td>73-76</td>
</tr>
<tr>
<td>C-</td>
<td>70-82</td>
</tr>
<tr>
<td>D+</td>
<td>67-69</td>
</tr>
<tr>
<td>D</td>
<td>63-76</td>
</tr>
<tr>
<td>D-</td>
<td>60-62</td>
</tr>
<tr>
<td>F</td>
<td>0-59</td>
</tr>
</tbody>
</table>

Assessment

Grades will be based upon the following forms of evaluation. Note the difference between graduate (CS577) and undergraduate (CS577) registrations.

**CS477**

<table>
<thead>
<tr>
<th>Component</th>
<th>Description of Component</th>
<th>Percent of Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Participation</td>
<td>Student comes to class prepared; contributes readily to the conversation but doesn’t dominate it; makes thoughtful contributions based on the literature that advance the conversation; shows an interest in and respect for others’ contributions; participates actively in all groups; contributes to the wiki.</td>
<td>20%</td>
</tr>
<tr>
<td>Group Programming</td>
<td>These are brief presentations that will be completed in pairs (or three if we are an odd number). All members will receive the same grade, and they will be done at the end of class. The purpose of these assignments is to master the material that is needed for the individual work. Groups will be the same people until all groups have presented.</td>
<td>30%</td>
</tr>
<tr>
<td>Problem Sets</td>
<td>Individually prepared, these will be answers to assigned problems. Most will be from the text. You will find many of the questions are fairly open ended. Relatively equal weight will be placed on correctness, completeness, skill, creativity, and presentation.</td>
<td>50%</td>
</tr>
</tbody>
</table>

**CS577**

wiki.cs.umt.edu/classes/cs477/index.php/Syllabus
<table>
<thead>
<tr>
<th>Component</th>
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<td>30%</td>
</tr>
<tr>
<td>Final Project</td>
<td>This is to be a comprehensive project in modeling. Project progress will be measured across the three milestones detailed below.</td>
<td>30%</td>
</tr>
</tbody>
</table>

CS 577 Final Project Milestones

1. **Planning** Students must identify important theoretical material early in the course, by week 5. Students must have a clear project in mind and at least 3 papers from the relevant literature. Students are encouraged to use this project to complement their graduate research. Students that are at a loss for what to pursue can look at the text book author's web site (http://sip.clarku.edu/projects.html) or speak to the instructor about ideas for good projects. Note that Physical Review articles are very easy to obtain online. I am interested in encouraging collaboration between science and computer science graduate students. Hence, group projects are a possibility, but should be discussed with me in advance.

2. **Implementation** By the time the course is two thirds through the semester, or in week 10, the students will have a working program that reproduces some essential behaviors suggested in the papers. Additionally, students will have to submit a clear outline of the proposed project.

3. **Interpretation** At the end of the semester the student will have completed the project in a satisfactory way. The results of the computer simulation will be appropriately reduced and interpreted.

The final report on the project will be a formal typed report, consistent in style with the projects. Students will also be required to deliver a 10-15 minute presentation on their project. There is no page requirement on the final project, but it should be a substantial piece of work.

The final project will be graded based on the "Project and Final Project Rubric" that appears lower on this syllabus. The final project should be graduate research quality; something that could lead to a professional paper or presentation.

**Co-convening courses**

Special accommodations must be made for the fact that this course co-convenes, or unites both graduate and undergraduate students. Specifically we will:

- work in groups that balance graduate and undergraduate participants.
- feature group programming to promote interaction between group members.
- use of a wiki to allow collaborative content generation.
allow time for interaction at the computer by shortening lectures and allowing groups to interact in a structured format.
- require that graduate projects are done outside of class time.
- provide access to the instructor for questions about the material, and the graduate level projects.

Other Issues Related to Grades

Flexibility of Grading Breakdown

I reserve the right to make changes to the grading policy that will be favorable to students grades.

Pass Fail

Students taking the course pass/no pass are required to earn a grade of C or better in order to pass.

Attendance Policy

The learner centered design of the course will make attendance necessary. If you know in advance that you will need to miss class, I encourage you to come speak to me. Acknowledging that everyone misses class occasionally, at least one of the in class assignments will be discarded before grades are computed. If absences are frequent, and unjustified, half the points for the group assignment will be lost by the student missing the classes.

Late Assignments

Other than in in exceptional circumstances, such as family emergencies, late homework will not be accepted. If you do have an emergency that causes you to miss an important classroom activity, I will be much more understanding if you let me know in advance.

Academic Integrity

As a student of the University of Montana, you are responsible for upholding all rules in the student conduct code. There are aspects of that code that are of particular importance in Computer Science courses. The electronic nature of the many assignments facilitates their dissemination. To be clear, from the student conduct code:

1. Plagiarism: Representing another person's words, ideas, data, or materials as one's own.

   6. Submitting work previously presented in another course: Knowingly making such submission in violation of stated course requirements.

Of course, all other aspects of the student conduct code will be enforced as well. These are just the two that are commonly violated.

I will interpret these guidelines to the letter. Students found in violation will be penalized with the maximum punishment permitted in the student conduct code. That is to say, the matter will be handed over to the Academic Dean and academic misconduct proceedings will take place.

In order to reconcile encouraged interaction between students and the academic misconduct policies, you must credit other students in your work. If, for example, you worked with others to develop some algorithm, or solve some homework problem, specifically mention those that you have worked with in the assignment that is handed in. Similarly, you must properly document and credit any online resources that you use.
If you collaborate with others, the instructor has the right to question you about the material turned in. If it is evident that your understanding of what you turn in is weak, your grade will be lowered.

Students are to uphold a level of conduct becoming of adults. The use of profanity and abusive speech is not permitted under the student conduct code, and will not be tolerated in this course.

Disabilities

Students with disabilities are encouraged to meet with me to discuss any accommodations they require.

Other Issues

- Turn off your cellphone, or set it to vibrate in class. Take the call outside the classroom.
- Do not speak when others are speaking. Listen.

Grading Rubrics

Problem Set Rubric

<table>
<thead>
<tr>
<th>Points</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purpose and Organization</strong></td>
<td>Clear progression from the group assignments to the completed problem set. Activities done as a group are leveraged to improve the quality of answers. Information well arranged, is complete, and it is simple to find answers to questions.</td>
<td>Clear ties to group work, but some of the material is inconsistent. Material is presented well, but has some ambiguities, misspellings, typos, and other careless aspects.</td>
<td>Little relation between what is turned in and the group activities. The problem is difficult to understand and find answers to the questions in.</td>
<td>Very incomplete problem set with no relation to group work.</td>
</tr>
<tr>
<td><strong>Understanding</strong></td>
<td>Used a deep understanding of the system to compare results to analytic solutions, consider conservation, reason about results, construct plots, and provide answers to the questions.</td>
<td>Made a clear effort to use both words and visuals to describe the physics and numerics of the problems; understanding is still developing as evidenced by errors and a lack of depth in some of the answers.</td>
<td>Physics and numerics understanding is very limited as demonstrated by the lack of depth, several errors, failure to depict information in visual manner or absence of some answers.</td>
<td>Failure to engage the problems based on incomplete answers, and/or a lack of detail in responses.</td>
</tr>
<tr>
<td><strong>Model Implementation</strong></td>
<td>Model works and is relevant to the stated purpose; model uses reasonable input</td>
<td>Model works and is relevant to purpose; certain input values and/or results are not</td>
<td>Model only partially works, is not able to address all of the assigned problems,</td>
<td>Failed to construct a working model which was relevant to the purpose.</td>
</tr>
</tbody>
</table>
values and yields realistic results; was able to use model to explore assigned questions. Important aspects of model implementation, especially where different from group assignments, are well documented.

realistic; model may not be capable of exploring some of the assigned questions.

or has major errors in input and output.

| Analysis |
| Relationship between variables are clearly stated; results are interpreted and meaningful conclusions are reached; discussion of errors or deficiencies in model drawn from a sound understanding of the system; well labeled visuals are frequently used to supporting conclusions. |
| Conclusions were drawn and relationships were discussed; may have one or more serious errors and/or omissions. Supporting graphics are mislabeled, or hard to interpret. |
| Discussion suffers from many serious errors and/or omissions. Visuals are missing or very poorly presented. |
| Incomplete assignment, and numerous conceptual flaws in what is turned in. |

Problem Set Rubric, Separate Page

**Project and Final Project Rubric**

<table>
<thead>
<tr>
<th>Points</th>
<th>9-10</th>
<th>7-8</th>
<th>5-6</th>
<th>0-4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organization x.5</strong></td>
<td>Paper follows the agreed upon format, and uses Latex.</td>
<td>Agreed upon format not followed in some significant ways, or Latex not used.</td>
<td>The paper is not at all in the proper format.</td>
<td>Little or no formatting at all.</td>
</tr>
<tr>
<td><strong>Introduction x.5</strong></td>
<td>Overview of theoretical concepts relevant to the project. Spells out hypothesis or scientific questions being addressed with the investigation.</td>
<td>Theoretical background is not clear, has omissions, or lacks depth.</td>
<td>One or more conceptual problems with discussion. Little or no basis for assessment provided.</td>
<td>A substantive discussion is entirely lacking.</td>
</tr>
<tr>
<td><strong>Method and Verification x2</strong></td>
<td>Numerical methods, algorithms, and program overview provided in the form</td>
<td>Algorithms are superficially described and lack proper references to</td>
<td>Little or no information about the program and numerical</td>
<td>No basis for assessment is provided.</td>
</tr>
<tr>
<td>Analysis x2</td>
<td>Relationships between variables are investigated, sensitivity of output to input investigated, uniqueness of solution is considered. Sources of uncertainty related to analysis.</td>
<td>Some important relationships left unconsidered, no mention of uncertainty.</td>
<td>Analysis is crude and shallow. Many important output are neglected.</td>
<td>Little or no analysis.</td>
</tr>
<tr>
<td>---</td>
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</tr>
<tr>
<td>Interpretation x2</td>
<td>Summary of results, insights into the system, and avenues for future exploration.</td>
<td>Summary isn't consistent with the methods or experiment, insights are trivial.</td>
<td>Little is said about future experiments. Summary is inconsistent with text.</td>
<td>Little or no summary, no basis for evaluation.</td>
</tr>
<tr>
<td>Data Presentation x2</td>
<td>Graphics are thoughtfully and carefully prepared; free of unnecessary clutter, well annotated.</td>
<td>Graphics are cramped, hard to understand, attempt to display too much or too little data. Opportunities to display information graphically are not exploited.</td>
<td>Very few graphs, poorly annotated, and confusing graphics.</td>
<td>No or only a few graphs of low quality, no basis for evaluation.</td>
</tr>
<tr>
<td>Mechanics</td>
<td>Paper is generally well written and formatted; free of typographical, grammatical, and spelling errors.</td>
<td>Some errors in grammar and spelling, but the meaning of the writing is clear.</td>
<td>Writing is so poor that it is difficult to understand the meaning of important passages.</td>
<td>Report is very incomplete and contains little written support.</td>
</tr>
</tbody>
</table>
CS 577 Final Project Rubric (separate page)


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- This page has been accessed 62,480 times.