College of Engineering, Forestry & Natural Sciences

School of Informatics, Computing, and Cyber Systems

CS 499 Mechanized Reasoning about Programs

Fall 2016

Total Units of Course Credit: 3

Course Pre-requisites: CS 200, CS 249

Co-convened Course: CS 599

Mode of Instruction: face-to-face

Instructor's Name: Dr. Frédéric Loulergue, Professor

Instructor's Office: #209, building 90

Instructor's Contact Information: Frederic.Loulergue@nau.edu

Instructor's Availability: Office hours MoWe 2:30PM–3:45PM, by appointment as needed

Course Purpose

Computing devices are more and more pervasive in our lives. Customers will therefore be more on more demanding on the reliability of such devices. Very high assurance software components can be provided using formal methods. This course is an introduction to formal reasoning about programs. You will learn how to prove properties about programming languages and programs as you write usual mathematical proofs. Moreover usual pen-and-paper proofs are not reliable enough for reasoning about complex and large software. Therefore you will also learn how to use a proof assistant, namely Coq, to formalize the semantics of programming languages and to mechanize the verification of the correctness of programs.

Course Student Learning Outcomes

After the course, the successful student will be able to:

- describe formal semantics of programming languages, particularly operational semantics;
- extend a programming language with new constructs, and extend its semantics accordingly;
- to specify and verify imperative programs;
- to prove basic properties of semantics descriptions;
- to use a proof assistant to formalize and prove properties of programs and programming languages;
- to perform basic analysis of principles of programming languages research literature.

Assessments of Course Student Learning Outcomes

This course offering will consist of the following elements:

- Lectures that meet three hours per week to present and discuss topics related to principles of programming languages, and program verification;
- Homework assignments, including a project, to solidify the students' understanding of the material and provide an opportunity to apply concepts from lectures;
- Reading assignments to challenge students to think critically about current research direction in programming languages and program verification.

Grading System

Your final grade for this course will be determined through the assessment of the exams and assignments summarized below:

Assignment	Grade Weight %
Homework assignments	15%
Project	20%
Attendance & participation	10%
Quizzes	10%
Midterm exam	15%
Final exam	30%

Each student is expected to attend every course meeting and participate actively in class discussions.

The grading scale is as follows:

Percentage Grade	Letter Grade
$\geq 90\%$	A
80% – 89%	B
70% – 79%	C
60% – 69%	D
$< 60\%$	F

Readings and Materials

Textbooks:

- Hanne Riis Nielson and Flemming Nielson, SEMANTICS WITH APPLICATIONS: AN AP-PETIZER, Undergraduate Topics in Computer Science, Springer, 2007, doi:10.1007/978-1-84628-692-6

- Benjamin C. Pierce et al., SOFTWARE FOUNDATIONS, version 4.0, electronic textbook, 2016, http://www.cis.upenn.edu/bcpierce/sf

Software:

- The Coq Proof Assistant http:/coq.inria.fr

- IDE: CoqIDE or Emacs with Proof General and Company Coq

Class Outline

Topics will include: mathematical background, operational semantics of programming languages, axiomatic semantics, reasoning about programs using these semantics, an introduction to verified compilation, functional programming in Coq, specifications in Coq, proofs in Coq, application to the semantics of programming languages and to the correctness of programs. If time permits: an introduction to static program analysis.

The course webpage will always have the most up-to-date schedule for the course: http://frederic.loulergue.eu/teaching/MRAP.

Course Policies

Submission and Late Policy

All homework assignments must be typed and submitted on Bb Learn by the due date and time. Each assignment must contain a header with the following information: Name, Assignment and Due Date. Failure to include the header will result in a 0 for that assignment.

In order to get assignments back to you in a timely manner, I depend on having all assignments turned in on time. As a result, there are stiff late penalties: Each hour the

assignment is late is worth a 10% penalty. The timer doesn't stop until the assignment is in my possession.

Attendance, Readings and Lecture

It is critical that you attend every course meeting. The readings and lectures will go hand-in-hand and will not necessarily cover the same material. One will reinforce the other, and you should be prepared to come to lecture having read through the reading assignments for the day. This will allow you to more actively participate during lecture, which will make the course much more enjoyable for all of us. Exam content will be drawn from both.

Electronic Devices

Feel free to bring your laptops and take electronic notes or try things out as we talk about them during lecture. Note that watching videos or managing your social media accounts does not count.

During exams, no electronic device use is allowed; this includes music players with headphones.

Please be courteous to me and to your classmates by silencing your cell phones. I reserve the right to ask you to stop using any device if it is bothersome during class.

The Site

The pages of the course's home site are the central course information and announcement clearinghouse, along with your email. I would ask that you check your email daily, at the very least and visit the site daily as well. Keep your eyes glued to the News section of the main page for announcements of changes, and to the Schedule that will be updated often with links to lecture notes and assignment details.

Contact

Please don't hesitate to drop by during office hours or send an email with any questions or concerns. When emailing me, the subject line must include "CS 499". Your email must be written in a professional manner. If you do not follow these guidelines, you may not receive a response.

I will do my best to answer your questions and address your concerns. I reserve the right to ask you to come in for a chat during office hours for long answers, and reserve email for shorter answers.

Grade Review

If you feel I've made a mistake in grading your assignment, please come visit me during office hours. I will very happily explain my reasoning and correct mistakes. However, any corrections must be discussed and made within *a week* of the assignment's return date.

Exams

Without prior notice of illness or substantial extenuating circumstances, there are no make-ups for exams. Please be prepared to provide supporting documentation to substantiate circumstances, as needed. Be sure to let the professor know of the potential for a missed exam as early as possible.

Academic Integrity

One of the foundations of academic life is honesty. Assignments and exams are ways to measure your understanding of the material being covered in the course, not medieval implements of torture. By cheating, you are cheating yourself out of the chance to have your understanding accurately evaluated. Grades are an indication of your final proficiency over the material, and not a form of punishment. Be honest and fair to your fellow classmates: do your own work.

Any form of academic dishonesty (such as "borrowing" text or materials) will be dealt with seriously. Consequences to incidents of academic dishonesty are based on the professor's discretionary recommendations, and may include a zero grade in the assignment in question, an F in the course, or may be referred to the university's channels and result in expulsion from NAU.

Just don't do it!

Special Accomodations

I am committed to a classroom that is open to all. If you feel you need any special accommodations for any component of the course, please:

1. let me know as soon as possible, and
2. contact Disability Resources immediately, so accommodations can be made.

University Policies

There are a number of university policies that govern your education and safety that all students should be aware of. These are:

- Safe Environment Policy

- Students With Disabilities
- Academic Contract Hour Policy
- Academic Integrity
- Research Integrity
- Sensitive Course Materials
- Classroom Disruption
- Medical Insurance Coverage for Students
- Institutional Review Board
- Accommodation of Religious Observance and Practice
- NAU Classroom Management Statement
- Building Evacuation Policy
- NAU Class Policy Statement
- Engineering Sciences Code of Ethics

You will find a description of each policy in the following documents:

- `http://nau.edu/OCLDAA/_Forms/UCC/SyllabusPolicyStmts2-2014`
- `https://nau.edu/student-life/student-handbook/rules-and-regulations`
- `https://nau.edu/uploadedFiles/Academic/CEFNS/Engineering/Mechanical/Forms/Professional_Ethics-Code_of_Conduct.pdf`