CSc 453, Compilers and Systems Software

Fall 2018

Location and times:
Lectures: MW 11:00-12:15, Gould-Simpson 906
Discussion: Th 5:00-6:30, Gould-Simpson 906

Class website: http://www.cs.arizona.edu/classes/cs453/fall18/

Description of Course
This course covers the design and implementation of translator-oriented systems software such as compilers and interpreters. Topics covered include lexical analysis, parsing, and syntax-directed code generation. **This class has a significant programming component.**

Course Prerequisites
- Courses: CSc 252, CSc 345, CSc 352
- Knowledge: Proficiency in programming in C. Familiarity with software development in a Unix/Linux environment, including tools such as editors, debuggers, make, etc.

Instructor and TA Contact Information
See the class website for current office hours for the instructor and the TA.

Instructor:
Saumya Debray
Office: Gould-Simpson 735
Phone: (520) 621-4527; Email: debray@cs.arizona.edu

Teaching assistants (Office: Gould-Simpson 942):
Jesse Bartels
Email: jessebartels@email.arizona.edu

Course Format
The course will consist of two weekly in-class lectures (MW 11:00-12:15) and a weekly discussion section (Th 5:00-6:30). The lectures will focus on conceptual material while the discussion section will focus primarily on issues relating to the programming project.

Course Objectives and Expected Learning Outcomes
Students who successfully complete this course should be able to understand:
- the structure of compilers; phases of compilation, including lexical analysis (scanning), syntax analysis (parsing), semantic analysis, intermediate and final code generation;
- the use of regular expressions to specify lexical tokens and the use of finite state automata to recognize tokens;
- the use of context-free grammars to specify programming language syntax, and the use of parsers to recognize context-free languages;
- intermediate representations, including abstract syntax trees and three-address code;
- code generation;
- interpreters and interpretation; Just-in-time (JIT) compilation.
As part of the course, students will implement a compiler for a significant subset of C and will gain experience in the use of compiler-construction tools such as flex and bison.

**Absence and Class Participation Policy**

Attendance will be expected, but not recorded. Students are fully responsible for all material presented or assigned in class. For this reason, and because participating in the course and attending lectures and other course events are vital to the learning process, attendance is strongly recommended.

Students who miss exams or assignment submission deadlines due to illness or emergency are required to bring documentation from their health-care provider or other relevant professional third parties.

The UA’s policy concerning Class Attendance, Participation, and Administrative Drops is available at: [http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop](http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop)

The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable, [http://policy.arizona.edu/human-resources/religious-accommodation-policy](http://policy.arizona.edu/human-resources/religious-accommodation-policy).

Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored. See: [https://deanofstudents.arizona.edu/absences](https://deanofstudents.arizona.edu/absences)

**Makeup Policy for Students Who Register Late**

Students who register after the first class meeting may not make up missed any missed work.

**Course Communications**

Course communications will be made through:
- D2L (for announcements)
- Piazza (for questions and discussions). The Piazza website for this class is [https://piazza.com/arizona/fall2018/csc453/home](https://piazza.com/arizona/fall2018/csc453/home). Students are responsible for enrolling for this class in Piazza (see [https://piazza.com/arizona/fall2018/csc453/home](https://piazza.com/arizona/fall2018/csc453/home)).

**Required Texts or Readings**

This class has no required text. The primary reference material will be the instructor’s lecture notes, which will be made available to students. Additionally, students may use the following book (available online for free) as an optional secondary reference:


**Required or Special Materials**

None

**Required Extracurricular Activities (if any)**

None

**Assignments and Examinations**

**Programming Assignments**

The course has a programming project where students implement a complete compiler for a subset of the C programming language. This project is divided into a number of programming assignments, each implementing a distinct component of the compiler. Additionally, there are
some assignments aimed at helping students understand how to use the software tools and libraries used in the project.

**Collaboration:** All assignments are individual (i.e., there is no partnering).

**Timeliness:** Assignments are due at the time stated on the assignment spec. Late submissions are permitted for up to 5 late days per assignment, but will be assessed a late penalty of 10 points per day.

You may turn in multiple submissions for the same assignment. Each day’s submission will be graded separately, and you will be awarded the maximum of their scores (after adjusting for late penalties where appropriate). *Note that for each day’s submissions, later submissions will overwrite files submitted earlier.*

**Schedule:** The schedule for these assignments is as follows (Note: this is subject to change with advance notice):

<table>
<thead>
<tr>
<th>Assignment No.</th>
<th>Topic</th>
<th>Start date</th>
<th>Due date</th>
</tr>
</thead>
<tbody>
<tr>
<td>#0</td>
<td>C refresher drills 2</td>
<td>8/20/2018</td>
<td>8/26/2018</td>
</tr>
<tr>
<td>#1 part 1</td>
<td>html2txt part 1</td>
<td>8/31/2018</td>
<td>9/4/2018</td>
</tr>
<tr>
<td>#1 part 2</td>
<td>html2txt part 2</td>
<td>9/7/2018</td>
<td>9/11/2018</td>
</tr>
<tr>
<td>#2</td>
<td>scanner + parser</td>
<td>9/14/2018</td>
<td>9/23/2018</td>
</tr>
<tr>
<td>#3 milestone 1</td>
<td>type checking (milestone 1)</td>
<td>9/28/2018</td>
<td>10/7/2018</td>
</tr>
<tr>
<td>#3 milestone 2</td>
<td>type checking (milestone 2)</td>
<td>10/12/2018</td>
<td>11/4/2018</td>
</tr>
<tr>
<td>#4 milestone 1</td>
<td>code generation (milestone 1)</td>
<td>10/26/2018</td>
<td>11/4/2018</td>
</tr>
<tr>
<td>#4 milestone 2</td>
<td>code generation (milestone 2)</td>
<td>11/9/2018</td>
<td>11/18/2018</td>
</tr>
<tr>
<td>#4 milestone 3</td>
<td>code generation (milestone 3)</td>
<td>11/26/2018</td>
<td>12/2/2018</td>
</tr>
</tbody>
</table>

**Exams**

Exams will be held in Gould-Simpson 906 unless explicitly noted. The schedule for exams is as follows:

- **Midterm:** Wed Oct 10, 2018: 11am – 12:15pm
- **Final:** Fri Dec 12, 2018: 10:30am – 12:30pm

Without prior arrangements, missed exams result in a grade of zero. If you will be absent on the date of an exam due to religious reasons or because of a pre-approved absence by the Dean of Students, please contact me ahead of time so that we can work out an alternative time for your exam.

**Final Examination**

Fri Dec 12, 2018: 10:30am – 12:30pm.

Final Exam Regulations: see [https://www.registrar.arizona.edu/courses/final-examination-regulations-and-information](https://www.registrar.arizona.edu/courses/final-examination-regulations-and-information)

Final Exam Schedule: see [http://www.registrar.arizona.edu/schedules/finals.htm](http://www.registrar.arizona.edu/schedules/finals.htm)
**Grading Scale and Policies**

Grades will be computed based on the following weights for the various components of the class:

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midterm exam</td>
<td>20%</td>
</tr>
<tr>
<td>Final exam</td>
<td>30%</td>
</tr>
<tr>
<td>Programming assignments</td>
<td>50%</td>
</tr>
</tbody>
</table>

(Note: different assignments have different degrees of difficulty and therefore will have different weights. See the class web page for details.)

Your grade will be determined by the overall weighted average of your scores, computed using the weights given above, based on the following mapping:

<table>
<thead>
<tr>
<th>Weighted average</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 90</td>
<td>A</td>
</tr>
<tr>
<td>≥ 80 but below 90</td>
<td>B</td>
</tr>
<tr>
<td>≥ 65 but below 80</td>
<td>C</td>
</tr>
<tr>
<td>≥ 55 but below 65</td>
<td>D</td>
</tr>
<tr>
<td>&lt; 55</td>
<td>E</td>
</tr>
</tbody>
</table>

University policy regarding grades and grading systems is available at [http://catalog.arizona.edu/policy/grades-and-grading-system](http://catalog.arizona.edu/policy/grades-and-grading-system)

**Grading procedure**

The size of the programs involved in the project makes it impractical to manually examine your source code to determine its correctness. Instead, we will use the following procedure:

- You will develop and test your code using your own test cases. It is permissible for students to share test cases.
- I will make my test cases public after the submission deadline.
- Your code will be graded on my test cases using a grading script. You will be awarded a preliminary score based on the number of test cases failed.
- If you were penalized more than once for the same problem, you will have the option of bringing this to my attention over the two weeks following notification of your preliminary score. Specifically, you will need to provide me with the following items (you can do this either via email or in person):
  - a list of the specific problems in your code; and
  - for each problem, the test cases that failed as a result.
- Based on this, I may adjust your preliminary score where appropriate, based on my assessment of the seriousness of the problems. However, any such adjustment will always be positive, i.e., you will not be penalized—but may be rewarded—for identifying and explaining the problems in your code.

**Requests for incomplete (I) or withdrawal (W)** must be made in accordance with University policies, which are available at [http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete](http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete) and [http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal](http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal) respectively.
Dispute of Grade Policy: All regrade requests for programming assignments must be made within two weeks of when the grade is returned. All regrade requests for midterm exams must be made within one week of when the graded exam is returned.

Scheduled Topics/Activities

<table>
<thead>
<tr>
<th>Week no.</th>
<th>Week of</th>
<th>Lecture Topic</th>
<th>Assignments and Exams</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8/20/2018</td>
<td>Course overview</td>
<td>Assg 0: start: 8/20; due: 8/26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Overview of compilers</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>8/27/2018</td>
<td>lexical analysis (scanning)</td>
<td>Assg 1 part 1: start 8/31</td>
</tr>
<tr>
<td>3</td>
<td>9/3/2018</td>
<td>lexical analysis (scanning); syntax analysis (parsing)</td>
<td>Assg 1 part 1: due 9/4; Assg 1 part 2: start 9/7</td>
</tr>
<tr>
<td>4</td>
<td>9/10/2018</td>
<td>parsing</td>
<td>Assg 1 part 2: due 9/11; Assg 2: start 9/14</td>
</tr>
<tr>
<td>5</td>
<td>9/17/2018</td>
<td>parsing; type checking</td>
<td>Assg 2: due 9/23</td>
</tr>
<tr>
<td>6</td>
<td>9/24/2018</td>
<td>type checking</td>
<td>Assg 3 milestone 1: start 9/28</td>
</tr>
<tr>
<td>7</td>
<td>10/1/2018</td>
<td>type checking; code generation</td>
<td>Assg 3 milestone 1: due 10/7</td>
</tr>
<tr>
<td>8</td>
<td>10/8/2018</td>
<td>code generation</td>
<td><strong>Midterm: 10/10</strong></td>
</tr>
<tr>
<td></td>
<td>10/15/2018</td>
<td>code generation</td>
<td>Assg 3 milestone 2: due 10/21</td>
</tr>
<tr>
<td>9</td>
<td>10/22/2018</td>
<td>code generation</td>
<td>Assg 4 milestone 1: start 10/26</td>
</tr>
<tr>
<td>10</td>
<td>10/29/2018</td>
<td>code generation</td>
<td>Assg 4 milestone 1: due 11/4</td>
</tr>
<tr>
<td>12</td>
<td>11/12/2018</td>
<td>interpreters</td>
<td>Assg 4 milestone 2: due 11/18</td>
</tr>
<tr>
<td>13</td>
<td>11/19/2018</td>
<td>JIT compilers</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>11/26/2018</td>
<td>JIT compilers</td>
<td>Assg 4 milestone 3: start 11/26</td>
</tr>
<tr>
<td>15</td>
<td>12/3/2018</td>
<td>review</td>
<td>Assg 4 milestone 3: due 12/2</td>
</tr>
</tbody>
</table>

**Final exam: 12/12**

Department of Computer Science Code of Conduct
The Department of Computer Science is committed to providing and maintaining a supportive educational environment for all. We strive to be welcoming and inclusive, respect privacy and confidentiality, behave respectfully and courteously, and practice intellectual honesty. Disruptive behaviors (such as physical or emotional harassment, dismissive attitudes, and abuse of department resources) will not be tolerated. The complete Code of Conduct is available on our department website. We expect that you will adhere to this code, as well as the UA Student Code of Conduct, while you are a member of this class.

Classroom Behavior Policy
To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.). Activities that are disruptive or distracting to others, such as those listed below, will not be tolerated in the classroom:

- Reading newspapers or magazines.
- Discussions of extended duration (except when you’ve been asked to discuss something as part of a class activity).
- Phone conversations, texting.
• Eating meals.

Students observed engaging in disruptive activity will be asked to cease this behavior. Those who continue to disrupt the class will be asked to leave lecture or discussion and may be reported to the Dean of Students.

**Threatening Behavior Policy**

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See [http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students](http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students).

**Accessibility and Accommodations**

At the University of Arizona we strive to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability or pregnancy, you are welcome to let me know so that we can discuss options. You are also encouraged to contact Disability Resources (520-621-3268) to explore reasonable accommodation.

If our class meets at a campus location: Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.

**Code of Academic Integrity**

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See: [http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity](http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity).

Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor’s express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student e-mail addresses. This conduct may also constitute copyright infringement.

**Programming assignments: what’s allowed and what isn’t**

It is permissible to discuss problems with others in broad terms, e.g., the structure or approach of a program. It is not permissible to discuss concrete details of solutions to a particular assignment before the due date/time for that assignment. In other words, you can talk to each other in English, but not in C/Unix.

The work you turn in for credit should be substantially your own. It is permissible to share test inputs with other students; collaboration beyond this on programming assignments is not permitted.

It is permissible to use modest amounts of "publicly visible" code — code that is available in books or magazines, or which has been distributed/discussed in class — in programming assignments, as long as the authorship of such code is adequately and explicitly acknowledged. It is not permissible to solicit code from others. It is also not permissible to use code written by CSc 453 students in previous terms. Please check with me or the TAs ahead of time if you’d like to use someone else’s code in order to make sure that the amount of code is indeed modest.

For the purposes of this course, cheating is considered to be any attempt to pass off someone else’s work as your own. Cheating will not be tolerated: any student caught cheating or helping
another student cheat in homeworks, exams, or programming assignments, will be given a failing grade in the course. I intend to interpret the phrase "helping another student cheat" broadly: for example, if another student gains access to your code because you forgot to logout, or were careless about listings that were dumped into the recycling bin, you have helped that student cheat. For the same reason, you should be very careful about posting your code to publicly visible media, e.g., Piazza or Github.

**UA Nondiscrimination and Anti-harassment Policy**

The University is committed to creating and maintaining an environment free of discrimination; see [http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy](http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy)

Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others.

**Additional Resources for Students**

UA Academic policies and procedures are available at [http://catalog.arizona.edu/policies](http://catalog.arizona.edu/policies)

Student Assistance and Advocacy information is available at [http://deanofstudents.arizona.edu/student-assistance/students/student-assistance](http://deanofstudents.arizona.edu/student-assistance/students/student-assistance)

**Confidentiality of Student Records**


**Subject to Change Statement**

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.