Course Information

Last updated: 8/26/20

ECE 468: Introduction to Compilers and Translation Engineering
CRN: 53460 (on-campus) and 25627 (online)

Meeting time:

1. All students in both sections will have access to online course material (lectures, discussion fora)
2. On-campus recitation sessions will be held once per week on either Monday, Wednesday, or Friday at 1:30 in ME 1061. Students will be assigned to a recitation group with specific meeting days of the week:

<table>
<thead>
<tr>
<th>Group</th>
<th>August 24—September 26</th>
<th>September 27–October 24</th>
<th>October 25—November 24</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mondays</td>
<td>Wednesdays</td>
<td>Fridays</td>
</tr>
<tr>
<td>2</td>
<td>Wednesdays</td>
<td>Fridays</td>
<td>Mondays</td>
</tr>
<tr>
<td>3</td>
<td>Fridays</td>
<td>Mondays</td>
<td>Wednesdays</td>
</tr>
</tbody>
</table>

Course credit hours: 4

Course web page:
- Main page (assignments, lecture notes): https://engineering.purdue.edu/EE468/
- Brightspace page (lecture videos, grades): https://purdue.brightspace.com/d2l/home/54288
- Piazza page (discussion board): https://piazza.com/purdue/fall2020/ece468/home

Prerequisites:
ECE 36200 and ECE 36800

Information About the Instructor(s)

Instructors

Milind Kulkarni
Office: EE 324A and EE 329
Email Address: milind@purdue.edu
Office hours, times and location:
- Mondays and Thursdays, 10:00–11:15 (Purdue time); or by appointment
- Office hours will be online; links posted on Piazza

Xiaokang Qiu
Office: EE 329
Email Address: xkqiu@purdue.edu
Office hours, times and location:
  Tuesdays, 1:30–2:45; Fridays 10–11:15; or by appointment
Office hours will be online; links posted on Piazza

Teaching Assistants

Kangjing Huang
Email Address: huangkangjing@purdue.edu
Office hours, times and location:
  Mondays and Wednesdays, 3:00–4:00; Tuesdays and Thursdays 3:00–5:00; or by appointment
Office hours will be online, links posted on Piazza

Chris Wright
Email Address: wrigh338@purdue.edu
Office hours, times and location:
  Wednesdays, 10:00–12:00; Fridays, 9:00–10:00; or by appointment
Office hours will be online, links posted on Piazza

Course Description
The design and construction of compilers and other translators. Topics include compilation goals, organization of a translator, grammars and languages, symbol tables, lexical analysis, syntax analysis (parsing), error handling, intermediate and final code generation, assemblers, interpreters, and an introduction to optimization. Emphasis is on engineering a compiler or interpreter for a small programming language—typically a C or Pascal subset. Projects involve the stepwise implementation (and documentation) of such a system.

Learning Outcomes
A student who successfully fulfills the course requirements will have demonstrated:
  i. an understanding of the terminology, representation and use of formal languages and grammars. [1]
  ii. an understanding of the terminology and techniques of lexical analysis, parsing, semantic processing, code generation, and optimization. [1]
  iii. an ability to design and implement a compiler, translator or interpreter for a small language based on their knowledge of (i) and (ii). [1,2,6]

More specifically, at the end of the course, you will be able to:
  a. Explain the various passes of a compiler (scanners, parsers, semantic actions and code generation, register allocation and basic optimizations) and how they relate to the overall compilation process.
  b. Explain and implement the algorithms for each of these processes.
  c. Be able to implement each of these passes and integrate them into a full compiler.
  d. Explain program analysis techniques that are used for code optimization, such as dataflow analysis, reaching definitions analysis, liveness analysis, etc.
  e. Describe basic code transformations and their application to program optimization.
Learning Resources, Technology, & Texts

Notes and Books
The course material for this course will be in the form of lecture notes, (digital) handouts, and lecture videos. Optionally, students might find the following textbook useful:


Software
Java
While students have the option of building their course project in other languages, we will provide substantial starter code in Java; we recommend that students thus download the Java development kit (https://www.oracle.com/java/technologies/javase-downloads.html).

The starter software uses ANTLR, a toolkit for building compilers. ANTLR can be downloaded here: https://www.antlr.org

IDEs
We recommend the use of an IDE for development. You can try:
- Visual Studio Code: https://code.visualstudio.com
- Eclipse: https://www.eclipse.org/downloads/packages/

Git and GitHub
Programming assignments will be distributed via GitHub classroom. So you will need an installation of git and a GitHub account (see below under “assignment submission.”)

Instructor’s Email Availability and Policies
We ask that all course-related questions be posted to the Piazza discussion board – your questions may be useful to other students.

If you have a question of a personal nature that you do not want to post on Piazza, then you may email the instructors. We will endeavor to respond to your emails within 24 hours (not counting weekends, when responses may be delayed)

Virtual Office Hours
Virtual Office Hours will be held on WebEx at the times specified. Updated links will be posted on Piazza if necessary.

Assignments and Points
The achievement of course objectives will be assessed through a combination of tests (3 midterms) and a substantial course project. The tests will assess students’ achievement of the first two outcomes, while the project will assess students’ achievement of the third outcome.

Grades will be assigned as follows:
- 10% — Problem sets (6 throughout the semester)
30% — Tests (3 midterms @ 10%)
60% — Project
5% — Class participation (bonus)

**Problem sets**
There will be 6 problem sets, approximately one every two weeks. Each set will be posted on Brightspace, and will be due a week after posting (uploaded through Gradescope). The problem sets will be graded on a 0-1 system: 1 point for turning in a serious attempt, 0 points for not turning in a set or not making an honest attempt at the problems. While the problem sets factor in to your grade, the primary benefit is for your own study; midterm and exam questions will often be in the same format as the questions on the problem sets.

The six problem sets are:
1. Regular expressions and finite automata
2. Context-free grammars and parsers
3. Type checking
4. Local optimizations
5. Dataflow analysis
6. Loop optimization

**Exams**
There will be three midterms. All midterms will be online (available for 3 hours in two windows; 1 hour time limit to complete). Midterms will be open-notes. Dates tentative, and subject to change.
   a. Midterm 1 — Scanning and parsing, basic code generation [9/25]
   b. Midterm 2 — Functions, type checking, local optimization, register allocation [10/30]
   c. Midterm 3 — Dataflow analysis, pointer analysis, loop optimization [11/27]

**Project:**
The bulk of your grade will be determined by a course project. This project involves implementing a full-fledged optimizing compiler for a simple language. You may implement your project in any language, but we will provide substantial starter code in Java.

You may work on your project with a partner, but working with a partner is neither necessary nor required.

The steps of the project are (due dates tentative, and subject to change):
1. Scanning and Parsing (adding new syntax to the language) [9/11]
2. Code generation for assignments and expressions [9/23]
3. Code generation for control statements [10/2]
4. Code generation for functions [10/21]
5. Register allocation [11/6]
7. Pointer analysis [12/4]
Grading Scale

Individual midterms may be curved at the instructor’s discretion. The maximum grade cutoffs for this course are given below. Grades will not be rounded: a 90.99 is an A-, and a 91.01 is an A. Thresholds may be lowered globally for the entire class at the instructor’s discretion.

<table>
<thead>
<tr>
<th>Letter grade</th>
<th>Minimum range</th>
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<tbody>
<tr>
<td>A+</td>
<td>97</td>
</tr>
<tr>
<td>A</td>
<td>91</td>
</tr>
<tr>
<td>A-</td>
<td>88</td>
</tr>
<tr>
<td>B+</td>
<td>85</td>
</tr>
<tr>
<td>B</td>
<td>79</td>
</tr>
<tr>
<td>B-</td>
<td>76</td>
</tr>
<tr>
<td>C+</td>
<td>73</td>
</tr>
<tr>
<td>C</td>
<td>67</td>
</tr>
<tr>
<td>C-</td>
<td>64</td>
</tr>
<tr>
<td>D+</td>
<td>61</td>
</tr>
<tr>
<td>D</td>
<td>55</td>
</tr>
<tr>
<td>D-</td>
<td>40</td>
</tr>
<tr>
<td>F</td>
<td>0</td>
</tr>
</tbody>
</table>

Course Logistics

Video Lectures and Recitations
Lectures will be uploaded to Brightspace for viewing. These lectures, plus the course slides, will be the primary material for the course. Recitation sections will be for problem solving, Q+A, etc. Except for Week 1, students in on-campus sections are expected to have viewed the lectures for that week prior to that week’s recitation section.

Course Discussion
This term we will be using Piazza for class discussion. If you have questions about the course or the project, I encourage you to post them on Piazza. It’s a shared discussion forum, where your question can be answered by myself, the TA or your fellow students! Piazza will be the primary method for disseminating course announcements, so you must have a Piazza account.

Note that to get full class participation points, you must a) sign up for Piazza, and b) post at least one public question or answer pertaining to the class.

Assignment Submission

Problem sets and exams
Problem sets and exams will be submitted via GradeScope. Please make sure you have a GradeScope account associated with your Purdue email address.
Group work policy
You can (optionally) work on the project in teams of 2. You must decide if you want to work on a group prior to turning in Step 0. If you choose to work in a group, you must indicate it in your course questionnaire. Once you choose a partner, you must continue to work with this partner for the remainder of the project.

Project submission
Because this project requires writing a large amount of code, and each step of the project will depend on previous steps of the project, we will use version control (git) and Github to manage projects and submissions (see the project webpage for more details):
1. You and your partner should each create a git account (if you don’t have one already)
2. When setting up repositories for your assignments, you will be asked to create or join a team.
   a. If you are the first member of your group to set up the repository, create a team for you and your partner
   b. If your partner has already created a team, join their team
   c. This is the team you will be using the entire semester (after step 1, we will create new assignments with the existing groups from the previous step)
3. Make sure you fill out the course questionnaire so we know your team name: https://forms.gle/pCsYmH4wEEU6eNcZ6
4. Use tags to tell us which version of your code to grade (see submission instructions)

Unless otherwise specified, all project steps are due at 11:59pm on the due date.

Late submission policy
Except for medical and family emergencies (accompanied by verification), there will be no extensions granted for project submissions. Late submissions will be scaled according to lateness, docking 10% from your score per day late, up to a maximum of 50%. Submissions more than 5 days late will be assigned a score of 0.

Course Schedule
The rough schedule of the class is given below. As the course has been restructured from past semesters, treat this schedule as an ordering of topics rather than a specific timeline

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>What is a compiler?</td>
</tr>
<tr>
<td>Week 2</td>
<td>Regular expressions, finite automata and scanners</td>
</tr>
<tr>
<td>Week 3</td>
<td>Context free grammars and parsers</td>
</tr>
<tr>
<td>Week 4</td>
<td>Symbol tables and assignments and expressions</td>
</tr>
<tr>
<td>Week 5</td>
<td>Control structures</td>
</tr>
<tr>
<td>Week 6</td>
<td>Functions</td>
</tr>
<tr>
<td>Week 7</td>
<td>Type checking</td>
</tr>
<tr>
<td>Week 8</td>
<td>Optimizations</td>
</tr>
<tr>
<td>Week 9</td>
<td>Optimizations (continued)</td>
</tr>
<tr>
<td>Week 10</td>
<td>Register allocation</td>
</tr>
<tr>
<td>Week 11</td>
<td>Pointers and arrays</td>
</tr>
<tr>
<td>Week 12</td>
<td>Control flow graphs and dataflow analysis</td>
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</tbody>
</table>
### Attendance Policy

You are responsible for all material covered in lectures and (for students in on-campus sections) weekly recitation sections. However, attendance is not required. If you feel that your personal situation, mental and/or physical health requires that you not attend class, that is OK.

Class participation points will not be tied to attendance. Instead, they will be evaluated based on engagement with the course. This may be through asking questions during recitation sections, but may also include engagement during office hours or on Piazza.

Students should stay home and contact the Protect Purdue Health Center (496-INFO) if they feel ill, have any symptoms associated with COVID-19, or suspect they have been exposed to the virus. In the current context of COVID-19, in-person attendance will not be a factor in the final grades, but the student still needs to inform the instructor of any conflict that can be anticipated and will affect the submission of an assignment or the ability to take an exam. Only the instructor can excuse a student from a course requirement or responsibility. When conflicts can be anticipated, such as for many University-sponsored activities and religious observations, the student should inform the instructor of the situation as far in advance as possible. For unanticipated or emergency conflict, when advance notification to an instructor is not possible, the student should contact the instructor as soon as possible by email, through Brightspace, or by phone. When the student is unable to make direct contact with the instructor and is unable to leave word with the instructor’s department because of circumstances beyond the student’s control, and in cases of bereavement, quarantine, or isolation, the student or the student’s representative should contact the Office of the Dean of Students via email or phone at 765-494-1747. Our course Brightspace includes a link on Attendance and Grief Absence policies under the University Policies menu.

### Academic Guidance in the Event a Student is Quarantined/Isolated

If you become quarantined or isolated at any point in time during the semester, in addition to support from the Protect Purdue Health Center, you will also have access to an Academic Case Manager who can provide you academic support during this time. Your Academic Case Manager can be reached at acmq@purdue.edu and will provide you with general guidelines/resources around communicating with your instructors, be available for academic support, and offer suggestions for how to be successful when learning remotely. Importantly, if you find yourself too sick to progress in the course, notify your academic case manager and notify me via email or Brightspace. We will make arrangements based on your particular situation. The Office of the Dean of Students (odos@purdue.edu) is also available to support you should this situation occur.

### Classroom Guidance Regarding Protect Purdue

The Protect Purdue Plan, which includes the Protect Purdue Pledge, is campus policy and as such all members of the Purdue community must comply with the required health and safety guidelines. Required behaviors in this class include:
staying home and contacting the Protect Purdue Health Center (496-INFO) if you feel ill or know you have been exposed to the virus, properly wearing a mask in classrooms and campus building, at all times (e.g., mask covers nose and mouth, no eating/drinking in the classroom), disinfecting desk/workspace prior to and after use, maintaining appropriate social distancing with peers and instructors (including when entering/ exiting classrooms), refraining from moving furniture, avoiding shared use of personal items, maintaining robust hygiene (e.g., handwashing, disposal of tissues) prior to, during and after class, and following all safety directions from the instructor.

Students who are not engaging in these behaviors (e.g., wearing a mask) will be offered the opportunity to comply. If non-compliance continues, possible results include instructors asking the student to leave class and instructors dismissing the whole class. Students who do not comply with the required health behaviors are violating the University Code of Conduct and will be reported to the Dean of Students Office with sanctions ranging from educational requirements to dismissal from the university.

Any student who has substantial reason to believe that another person in a campus room (e.g., classroom) is threatening the safety of others by not complying (e.g., not wearing a mask) may leave the room without consequence. The student is encouraged to report the behavior to and discuss next steps with their instructor. Students also have the option of reporting the behavior to the Office of the Student Rights and Responsibilities. See also Purdue University Bill of Student Rights.

**Academic Integrity**

Unless expressly allowed, you are expected to complete all assignments by yourself. However, you are allowed to discuss general issues with other students (programming techniques, clearing up confusion about requirements, etc.). You may discuss particular algorithmic issues on Piazza (but do not copy code!). *We will be using software designed to catch plagiarism in programming assignments, and all students found sharing solutions will be reported to the Dean of students.*

Punishments for academic dishonesty are severe, including receiving an F in the course or being expelled from the University. By departmental rules, all instances of cheating will be reported to the Dean. On the first instance of cheating, students will receive a 0 on the assignment; the second instance of cheating will result in a failure of the course.

**Accessibility**

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247. More details are available on our course Brightspace under Accessibility Information.

**Nondiscrimination Statement**

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the
institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. Link to Purdue’s nondiscrimination policy statement.

Students with Disabilities
Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247.

Emergency Preparation
In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor’s control. Relevant changes to this course will be posted onto the course website, Piazza, and Brightspace. You are expected to read your @purdue.edu email on a frequent basis.

Mental Health Statement
- If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try WellTrack.
  Sign in and find information and tools at your fingertips, available to you at any time.
- If you need support and information about options and resources, please see the Office of the Dean of Students for drop-in hours (M-F, 8 am- 5 pm).
- If you’re struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

Course Evaluation
During the last two weeks of the course, you will be provided with an opportunity to evaluate this course and your instructor. Purdue uses an online course evaluation system. You will receive an official email from evaluation administrators with a link to the online evaluation site. You will have up to two weeks to complete this evaluation. Your participation is an integral part of this course, and your feedback is vital to improving education at Purdue University. I strongly urge you to participate in the evaluation system.

Students who provide proof of completion of their course evaluation will receive a bonus class participation point.

Disclaimer
This syllabus is subject to change. Changes in any aspect of the course will be communicated via Piazza and Brightspace.