Course Information
- **ECE 573**: Compilers and Translator Writing Systems
- **CRN**: 16843
- **Meeting time**: TuTh 10:30-11:45 (ARMS B071)
- **Instructional Modality**: Face-to-Face
- **Course credit hours**: 3
- **Prerequisites**: A solid grounding in Java or some other high level programming language. A working knowledge of data structures and assembly language. A grasp of the basic fundamentals of computer organization and architecture.

Instructor(s) Contact Information
**Xiaokang Qiu (Instructor)**
- BHEE 329
- 765-494-9987
- xkqiu@purdue.edu
- **Office hours**: Tu 1-2:30 (hybrid), F 10:30-12 (online); Zoom link: https://purdue-edu.zoom.us/my/xkqiu

**Kangjing Huang (Teaching Assistant)**
- BHEE 207
- huangkangjing@purdue.edu
- **Office hours**: MW 11-12:30 (online), F 4-5 (hybrid); Zoom link: https://purdue-edu.zoom.us/my/kangjinghuang

**Gokulan Ravi (Teaching Assistant)**
- BHEE 207
- ravig@purdue.edu
- **Office hours**: TuTh 3-5 (hybrid), F 3-5 (in-person); Zoom link: https://purdue-edu.zoom.us/my/gokulanr

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 Resources, Technology & Texts
**Websites**
- **Website (one-stop shop, reference implementation)**: https://cap.ecn.purdue.edu/compilers/
- **Brightspace (lecture videos, quizzes, grades)**: https://purdue.brightspace.com/d2l/home/599915
- **Gradescope (problem sets)**: https://www.gradescope.com/courses/414448
- **Piazza**: piazza.com/purdue/fall2022/ece468573/home

Notes and Books
The primary course material will be in the form of lecture notes and (digital) handouts. 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](https://www.oracle.com/java/technologies/javase-downloads.html)). We plan to provide an experimental version of starter code in Python.

- **ANTLR**: The starter software uses ANTLR, a toolkit for building compilers. ANTLR can be downloaded here: [https://www.antlr.org](https://www.antlr.org)

- **IDEs**: We recommend the use of an IDE for development. You can try:
  - Visual Studio Code: [https://code.visualstudio.com](https://code.visualstudio.com)

- **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”).

Learning Outcomes

At the end of the course, a student who has successfully met the course objectives will be able to:

1. Describe and explain the terminology, representation and use of formal languages and grammars [1];
2. Describe and explain the terminology and techniques of lexical analysis, parsing, semantic actions and code generation [1];
3. Design and implement a compiler for a small language based on their knowledge of the previous two points [1, 2, 5, 6].

More specifically, at the end of the course, you will be able to:

- 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.
- Explain and implement the algorithms for each of these processes.
- Be able to implement each of these passes and integrate them into a full compiler.
- Explain program analysis techniques that are used for code optimization, such as dataflow analysis, reaching definitions analysis, liveness analysis, etc.
- Describe basic code transformations and their application to program optimization.

Assignments and Exams

Exams

We will have evening midterms. The midterms and final are open book and open notes. The tentative times and topics for the exams are below:

<table>
<thead>
<tr>
<th>Exam</th>
<th>Time</th>
<th>Location</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midterm 1</td>
<td>Thursday, September 22nd, 8:00-9:15pm</td>
<td>WALC 1055</td>
<td>Introduction, scanning and parsing, code generation</td>
</tr>
</tbody>
</table>
Midterm 2
Wednesday, November 2\textsuperscript{nd},
8:00-9:15pm
LILY G126
Type checking, register allocation, instruction
scheduling, peephole optimizations

Final
TBD
TBD
Loop optimizations, dataflow analysis,
pointer analysis and dependence analysis

Due to the extra hours for midterms, the meetings on Tuesday, November 22\textsuperscript{nd} and Tuesday, December 6\textsuperscript{th} are to be omitted (tentatively).

**Problem Sets**

There will be 5-6 problem sets, approximately one every two weeks. Each set will be posted online on Gradescope and normally will be due by 11:59pm on Sundays. **Late submissions will not be accepted.** 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 into 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.

**Project**

This project involves implementing a full-fledged optimizing compiler for a simple language. The project consists of multiple steps, each of which will be graded separately. However, each step builds on the results of previous steps, so it behooves you to ensure that each step works properly. The bulk of your project grade is based on the correctness of your compiler on several predetermined test programs; 10% of the grade will be based on your final compiler’s correctness and performance on several undisclosed test programs. The project steps (and due dates) are as follows:

<table>
<thead>
<tr>
<th>Step</th>
<th>Task</th>
<th>Due date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Scanning and parsing</td>
<td>Fri, September 16, 5PM ET</td>
</tr>
<tr>
<td>Step 2</td>
<td>Code generation for assignments and expressions</td>
<td>Fri, September 23, 5PM ET</td>
</tr>
<tr>
<td>Step 3</td>
<td>Code generation for control statements</td>
<td>Fri, September 30, 5PM ET</td>
</tr>
<tr>
<td>Step 4</td>
<td>Code generation for functions</td>
<td>Fri, October 21, 5PM ET</td>
</tr>
<tr>
<td>Step 5</td>
<td>Register allocation</td>
<td>Tue, November 8, 5PM ET</td>
</tr>
<tr>
<td>Step 6</td>
<td>Pointers and arrays</td>
<td>Tue, November 22, 5PM ET</td>
</tr>
<tr>
<td>Step 7</td>
<td>Choose your own adventure</td>
<td>Fri, December 2, 5PM ET</td>
</tr>
</tbody>
</table>

* Due dates subject to change.

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 1. If you choose to work in a group, you must indicate it in your submission. Once you choose a partner, you must continue to work with this partner for the remainder of the project. You and your partner will get the same grade, i.e., we do not distinguish your individual contribution from your partner.

We reserve the right to make appropriate adjustments to ensure that grades are appropriate in rare and unusual circumstances, e.g., performance that gets dramatically better or worse over the course of the term, extreme mismatches between exam and homework averages, sickness affecting an exam, etc. In cases of doubt, we will try to be generous, within the limits of common sense.

Project steps normally due by 5pm of Fridays. **Late penalty will be 10% per day, up to 5 days.** Weekends do count as late days. Due dates are subject to change at the instructor’s discretion.
Grading Scale

Grades will be assigned as follows:

- 36% — Tests (2 midterms and 1 final, 12% each)
- 49% — Project
- 10% — Problem sets (5–6 total)
- 5% — Class participation
- 1% — Bonus for submitting course evaluation

The participation credit is determined by many factors, some of which are measurable (e.g., every endorsed answer on Piazza gets you a point, and every reported and confirmed bug of the project/assignments gets you two points) and some of which are at the instructional staff’s discretion (e.g., how active you were in classroom/office hours).

There may be a constant curve (i.e., all grades will be increased by a fixed amount) for individual exams at the instructor’s discretion. Your course grade will be determined using an absolute scale: 97–100: A+; 91–97: A; 88–91: A-; and continuing down.

How to Succeed in This Course

1) If you think an assignment is buggy or unclear, post a query to Piazza.
2) Start early! You are highly encouraged to start working on the steps as soon as they are posted and not wait until the last day.
3) You are encouraged to write your own test cases to make sure that your compiler fully supports the provided grammar. Doing this throughout the semester will help you ensure that your compiler will pass the hidden test cases.
4) In any case, if you feel lost, please come and speak with the instructor/TA during their office hours, and/or/xor send them email.

Attendance Policy

This course follows Purdue’s academic regulations regarding attendance, which states that students are expected to be present for every meeting of the classes in which they are enrolled. However, 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.

When conflicts or absences 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 absences when advance notification to the instructor is not possible, the student should contact the instructor as soon as possible by email or 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 falling under excused absence regulations, the student or the student’s representative should contact or go to the Office of the Dean of Students website to complete appropriate forms for instructor notification. Under academic regulations, excused absences may be granted for cases of grief/bereavement, military service, jury duty, and parenting leave. For details, see the Academic Regulations & Student Conduct section of the University Catalog website. Guidance on class attendance related to COVID-19 are outlined in the Protect Purdue Pledge for Fall 2021 on the Protect Purdue website.
Academic Guidance in the Event a Student is Quarantined/Isolated

If you must miss class at any point in time during the semester, please reach out to me via email so that we can communicate about how you can maintain your academic progress. If you find yourself too sick to progress in the course, notify your adviser and notify me via email or Brightspace. We will make arrangements based on your particular situation. Please note that, according to Details for Students on Normal Operations for Fall 2021 announced on the Protect Purdue website, “individuals who test positive for COVID-19 are not guaranteed remote access to all course activities, materials, and assignments.”

Course Schedule

<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 – cont’d</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>
</tr>
<tr>
<td>Week 13</td>
<td>Pointer analysis</td>
</tr>
<tr>
<td>Week 14</td>
<td>Loop optimization</td>
</tr>
<tr>
<td>Week 15</td>
<td>Loop optimization – cont’d</td>
</tr>
<tr>
<td>Week 16</td>
<td>Slack</td>
</tr>
</tbody>
</table>

* Schedule and assignments subject to change. Any changes will be posted in Brightspace and/or Piazza.

Classroom Guidance Regarding Protect Purdue

Any student who has substantial reason to believe that another person is threatening the safety of others by not complying with Protect Purdue protocols is encouraged to report the behavior to and discuss the 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 and the Violent Behavior Policy under University Resources in Brightspace.

Academic Integrity

We hope (and assume) that you are all honest and have no intentions of cheating. Cheating ruins the experience for everyone and we will pursue appropriate penalties if we catch someone cheating. Please don't -- it’s not worth it, both for you and for us. You can find Purdue’s student guide for academic integrity at https://www.purdue.edu/odos/academic-integrity/.

If we do catch someone cheating for the first time, the following penalties will be applied:
- On an exam: zero for the exam.
- On an assignment: zero on the assignment. Moreover, we will subtract 10% from your final average in the course, or reduce your letter grade by one category (e.g., B to B-), whichever results in the lower grade.

For second cheating offense of any kind, you will fail this course.

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 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. Purdue’s full Nondiscrimination Policy Statement is available at https://www.purdue.edu/purdue/ea_eou_statement.php.

Accessibility

Purdue University is committed to making learning experiences accessible. 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.

Mental Health/Wellness 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 contact or see the Office of the Dean of Students. Call 765-494-1747. Hours of operation are M-F, 8 am-5 pm.

If you find yourself struggling to find a healthy balance between academics, social life, stress, etc. sign up for free one-on-one virtual or in-person sessions with a Purdue Wellness Coach at RecWell. Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is completely free and can be done on BoilerConnect. If you have any questions, please contact Purdue Wellness at evans240@purdue.edu.

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 on the second floor of the Purdue University Student Health Center (PUSH) during business hours.

Basic Needs Security

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact the Dean of Students for support. There is no appointment needed and Student Support Services is available to serve students 8 a.m.-5 p.m. Monday through Friday. Considering the significant disruptions caused by the current global crisis as it related to COVID-19, students may submit requests for emergency assistance from the Critical Needs Fund.
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 or can be obtained by contacting the instructors or TAs via email or phone. You are expected to read your @purdue.edu email on a frequent basis.