Course Information

Course Number:	434
Course Title:	Compiler Design
Sections:	500, 200
Time:	MW 4:10-5:25PM
Location:	ZACH 244
Credit Hours:	3

Instructor Details

Instructor:	Khanh Nguyen
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Office Hours:	T 2:30-3:30PM or by appointment

Course Description

Programming language translation; functions and general organization of compiler design and interpreters; theoretical and implementation aspects of lexical scanners; parsing of context free languages; code generation and optimization; error recovery

Course Prerequisites

CSCE 315 or approval of instructor.
Note: this course is a continuation of CSCE 314; hence previous enrollment in CSCE 314 is helpful.

Special Course Designation

None

Course Learning Outcomes

Upon successfully completing the course, the student will:

- Understand the translation process from user code to machine code.
- Describe major components of a typical compiler and their function.
- Understand various parsing techniques such as LL(1), SLR(1), LALR(1), and LR(1).
- Understand and implement various code optimization techniques.
- Design and implement sound dataflow analyses.

- Develop a front-end and a back-end of an optimizing compiler that can generate executable machine code from source code.

Textbook and/or Resource Materials

- Required: *Compilers: Principles, Techniques, & Tools (aka the Dragon book), 2nd Edition,* by Alfred Aho, Monica Lam, Ravi Sethi, Jeffrey Ullman. 2006.
    - *This book is required in the sense that we will follow the material in this textbook closely but not in all aspects. The exercises and discussion in this book will be helpful to supplement the lecture.*
- Highly recommended: *Engineering: A Compiler, 2nd Edition,* by Keith Cooper, Linda Torczon. 2011.
- Additional: *Principles of Program Analysis, 2nd Edition,* by Fleming Nielson, Hanne Riis Nielson, Chris Hankin. 1999.
- Lecture slides and extra reading materials will be available in Google Drive.

Grading Policy

Grading is based on the following components:

- **Written Assignments:** 7±1 written assignments: 5% of grade.
- **Exams:** 2 midterm exams (15% of grade each), and 1 final exam (20% of grade). The final exam will be cumulative. All exams are open-book, open-note, closed-internet.
- **Project:** 45% of grade. This will be a semester-long project building an optimizing compiler with multiple parts. The language used for the project is ***Java***. For the first 3 project assignments, students must work individually. Students may work in pair in subsequent project assignments.

Academic Integrity

Except for eligible pair project assignments, all other assignments in this course are individual efforts. Any academic dishonesty will not be tolerated and will be severely dealt with. Refer to Academic Integrity Statement and Policy below. All parties involved will be penalized equally.

- Students can and are encouraged to discuss at high level the project with friends but absolutely no code sharing in any form (across team boundary). Students are not allowed to use code found elsewhere (e.g., online repositories, code from past offerings of the course). The use of private code repository is recommended to prevent questions of authorship.
- Similarly, students can and are encouraged to discuss written assignments (e.g., strategy or approach); however, the write up must be done individually and must not be shared in any way or form. Plagiarism (e.g., copy verbatim) will not be tolerated.

Upon accepting admission to Texas A&M University, a student immediately assumes a commitment to uphold the Honor Code, to accept responsibility for learning and to follow the philosophy and rules of the Honor System. Ignorance of the rules does not exclude any member of the Texas A&M University community from the requirements or the processes of the Honor System.

Grading Scale

Course grading scale: **F** < 40% ≤ **D** < 55% ≤ **C** < 70% ≤ **B** < 85% ≤ **A**

About cutpoints: Cutpoints are non-negotiable. Furthermore, people are cutpoints; whole-numbered percentages are not. In other words, the cutpoint for a particular grade is the lowest-scoring person who received that grade.

Late Work Policy

- All assignments in this class have established deadline – refer to tables below. All deadlines are hard. Submitting a deliverable after deadline is late work. There will be no grace period. No late work is accepted unless due to university-approved absences. Students are required to furnish documentation for an excused absence. Refer to Student Rule 7 in its entirety for information about excused absences and related information.
- The instructor reserves the rights to define makeup work for an excused absence, which is not considered late work and is exempted from the late work policy.

Project Deadline Extension

- The instructor grants each student **48** non-transferable hours to extend deadlines of eligible project assignments (see Project Deadlines table below). No questions asked.
- Students must notify the instructor by 9:00pm of the project assignment due day the number of hours to be used. It is the responsibility of the students to confirm that the request is received.
- Having these hours is a privilege, not a right nor an entitlement. If misconduct happens, the instructor will terminate deadline extension.

Makeup Quiz/Exam Policy

Unless due to excused absences, no makeup exam will be given. If an excused absence is expected, students should contact the instructor as soon as possible to pre-arrange makeups.

Incomplete Grade Policy

Per Student Rule 10, the instructor shall give an incomplete grade only in cases due to an authorized absence or other causes beyond the control of the student. Students are required to furnish appropriate documentation.

Course Evaluation

- Evaluations are a way for students to provide feedback regarding their instructor and the course after the delivery, including student perceptions of learning and the student experience in the course. Detailed feedback will enable the instructor to continuously tailor and improve teaching methods as well as course content to meet the learning goals of the course and the academic needs of the students. They are a requirement of the course and are key to continue to provide students with the highest quality of teaching.
- Texas A&M utilizes AEFIS to collect student course evaluations. The evaluations are anonymous; the instructor and administration do not track who entered what responses. At no point of the process that the instructor knows the students' identity or whether a student has completed the evaluation. Students are strongly encouraged to participate in the course evaluation. Refer to Office of Institutional Effective & Evaluation page for more information. The instructor welcomes anonymous feedback during the course.
- Incentives for filling course evaluation: At Texas A&M, the Faculty Senate passed a Resolution in 2010 (FS.27.122) that specifically stated "The Faculty Senate opposes granting academic credit of any kind to students for completing course evaluations ..." This would include incentives such as bonus points.

Honors Section Additional Information

The honors section (200) will be run similar to the regular section (500) of the course. Additional requirements for honors students are:

- Extra and/or different questions on midterms and final
- Additional features / optimizations required to be implemented in project assignments
- Additional test cases when turning in project assignments to earn full credit
- Summary for 2 papers related to compiler construction. These summaries account for 5% of the project grade.

Course Schedule & Readings

Dragon = Aho, Lam, Sethi, and Ullman
EaC = Cooper, and Torczon

Wk.	Topic	Reading
1	Overview	Dragon 1 EaC 1
2	Lexical Analysis; Regular Expression	Dragon 2.6, 3-3.4, 3.6-3.7, 3.8.3-3.8.4 EaC 2-2.4.3, 2.4.5, 2.5.3-2.5.4
	Syntax Analysis; Context Free Languages; Ambiguity	Dragon 2.2, 4-4.3 EaC 3-3.2, 3.5.3

Wk.	Topic	Reading
3	*# Labor Day #*	
	Top Down Parsing 1	Dragon 2.4, 4.4 EaC 3.3
4	Top Down Parsing 2	
	Bottom Up Parsing - intro	Dragon 4.5 EaC 3.4-3.4.1
5	Project Guide: AST + Naive code gen Review	Dragon 2.5, 2.8.2, 5.1,5.3, 5.5.1-5.5.2, 5.4(optional) EaC 4.4 (skim) 5.2.1
	Midterm #1 (9/21)	
6	Semantic Analysis: Symbol Tables; Scoping	Dragon 2.7, 6.9 EaC 4-4.1, 5.5, 6.3.1
	Type Checking 1	Dragon 6.3-6.3.2, 6.5-6.5.3 EaC 4.2.1 Type Systems - Luca Cardelli: 1- 3 (upto table 10) table 15, 6 (pages 28-30), 9 (summary only)
7	Type Checking 2	
	Runtime Environment: Array; Function Calls	Dragon 7.2, 7.3-7.3.3, 8.3.2-8.3.3 EaC 6.3.2, 6.4-6.5, 7.5
8	*# Fall break #*	
	IR generation: TAC, CFG	Dragon 2.8.4, 6.2-6.2.1, 6.4, 8.4 EaC 5.1(skim), 5.2.2, 5.3.2-5.4.1
9	SSA Construction 1	Dragon 6.2.4, 9.6.1 (dominators) EaC 5.4.2, 9.2.1, 9.3, 9.5.2
	SSA Construction 2	
	Papers: Efficiently Computing Static Single Assignment Form and the Control Dependence Graph – Cytron et. al., https://dl.acm.org/doi/10.1145/115372.115320 Single-pass generation of Static Single-Assignment for Structured Languages – Brandis, and Mossenbok, https://dl.acm.org/doi/10.1145/197320.197331	
10	Dataflow Analysis 1	PPA ch 1 – 2 Dragon 9.2-9.4 Dragon 8.5-8.5.5, 8.7 EaC 8.6-8.6.1, 9.2, 10-10.2
	Dataflow Analysis 2	
11	Global Optimization; PRE	Dragon 9-9.1, 9.4-9.5 Dragon 9.7 (regional-optional) EaC 8.6-8.6.1, 10.3

Wk.	Topic	Reading
	Project Guide: Code Gen Review	Dragon 6.6-6.7 code gen, 6.8(skim switch stmt), 8.6.2 EaC 7.3-7.4, 7.8-7.9 (skim) for code gen
12	**Midterm #2 (11/7)**	
	Register Allocation 1	Dragon 8.1.3-8.1.4, 8.8 EaC 13-13.5 (skim 13.3.1-13.3.2)
13	Register Allocation 2	
	Papers: Register allocation & spilling via graph coloring – Chaitin, https://dl.acm.org/doi/10.1145/872726.806984 Improvements to graph coloring register allocation – Briggs, Copper, and Torczon, https://dl.acm.org/doi/10.1145/177492.177575	
	Instruction Scheduling	Dragon 8.2.1-8.2.2,10-10.3, 10.5.5-10.5.8 EaC 12-12.3.1
14	Runtime Environment: Objects, Dynamic Dispatch	EaC 6.3.3-6.3.4
	# Reading Day #	
15	Bottom Up Parsing 1	Dragon 4.5-4.8 EaC 3.4.2
	Bottom Up Parsing 2	
16	*Slippage – In-person Project Evaluation*	
	Slippage – In-person Project Evaluation	
17	**Final Exam (12/12) 3:30 – 5:30p**	

Written Assignment (WA) Deadlines: all written assignments are due by **11:59pm**

Release	Due Date	
8/31	9/6	**WA 1 RegEx Ambiguity**
9/12	9/18	**WA 2 LL1**
10/5	10/11	**WA 3 Type Checking – Call Stacks**
10/19	10/25	**WA 4 SSA**
10/31	11/6	**WA 5 Local and Global Analysis**
11/9	11/15	**WA 6 Register Allocation**
11/30	12/6	**WA 7 LR1**

Project Assignment (PA) Deadlines: all project assignments are due by **11:59pm**

Due Date	
9/3	**PA 1 Scanner**
9/13	**PA 2 Interpreter**
9/23	**PA 3 Compiler**
9/26	*Team info due*
10/5	**PA 4 AST and Symbol Table**
10/12	**PA 5 Type Checker**
10/17	**IR Visualizer** (checkpoint: not graded)
10/27	**PA 6 SSA**
11/9	**PA 7 Optimization** (checkpoint: not graded)
11/25	**PA 8-9 Reg Alloc + Code Gen** (checkpoint: not graded) *Extra hours max 24hrs*
12/2	**Whole Compiler + Report** *Not eligible for extra hours*
12/3	Late submission: 1% PAs 7-8-9 scores penalty per hour (round up to whole hour)

Course Material Policy

Materials used in this course are subject to copyright. Students are not allowed to reproduce, distribute, or post any lecture material, assignments, assignment solutions, or exams publicly. Students may take notes and make copies of course materials for personal use. Students may not post course materials on commercial websites such as Course Hero and Chegg. Doing so is a copyright violation and in some cases may also be an academic integrity violation that will be dealt with accordingly.

University Policies

Attendance Policy

The University views class attendance and participation as an individual student responsibility. Students are expected to attend class and to complete all assignments.

Please refer to Student Rule 7 in its entirety for information about excused absences, including definitions, and related documentation and timelines.

Makeup Work Policy

Students will be excused from attending class on the day of a graded activity or when attendance contributes to a student's grade, for the reasons stated in Student Rule 7, or other reason deemed appropriate by the instructor.

Please refer to Student Rule 7 in its entirety for information about makeup work, including definitions, and related documentation and timelines.

Absences related to Title IX of the Education Amendments of 1972 may necessitate a period of more than 30 days for make-up work, and the timeframe for make-up work should be agreed upon by the student and instructor" (Student Rule 7, Section 7.4.1).

"The instructor is under no obligation to provide an opportunity for the student to make up work missed because of an unexcused absence" (Student Rule 7, Section 7.4.2).

Students who request an excused absence are expected to uphold the Aggie Honor Code and Student Conduct Code. (Student Rule 24).

Academic Integrity Statement and Policy

"An Aggie does not lie, cheat or steal, or tolerate those who do."

"Texas A&M University students are responsible for authenticating all work submitted to an instructor. If asked, students must be able to produce proof that the item submitted is indeed the work of that student. Students must keep appropriate records at all times. The inability to authenticate one's work, should the instructor request it, may be sufficient grounds to initiate an academic misconduct case" (Section 20.1.2.3, Student Rule 20).

Students can learn more about the Aggie Honor System Office Rules and Procedures, academic integrity, and students' rights and responsibilities at aggiehonor.tamu.edu.

Americans with Disabilities Act (ADA) Policy

Texas A&M University is committed to providing equitable access to learning opportunities for all students. If you experience barriers to your education due to a disability or think you may have a disability, please contact the Disability Resources office in the Student Services Building or at (979) 845-1637 or visit disability.tamu.edu.

Disabilities may include, but are not limited to attentional, learning, mental health, sensory, physical, or chronic health conditions. All students are encouraged to discuss their disability related needs with Disability Resources and their instructors as soon as possible.

Title IX and Statement on Limits to Confidentiality

Texas A&M University is committed to fostering a learning environment that is safe and productive for all. University policies and federal and state laws prohibit gender-based discrimination and sexual harassment, including sexual assault, sexual exploitation, domestic violence, dating violence, and stalking.

With the exception of some medical and mental health providers, all university employees (including full and part-time faculty, staff, paid graduate assistants, student workers, etc.) are Mandatory Reporters and must report to the Title IX Office if the employee experiences, observes, or becomes aware of an incident that meets the following conditions (see University Rule 08.01.01.M1):

- The incident is reasonably believed to be discrimination or harassment.
- The incident is alleged to have been committed by or against a person who, at the time of the incident, was (1) a student enrolled at the University or (2) an employee of the University.

Mandatory Reporters must file a report regardless of how the information comes to their attention – including but not limited to face-to-face conversations, a written class assignment or paper, class discussion, email, text, or social media post. Although Mandatory Reporters must file a report, in most instances, a person who is subjected to the alleged conduct will be able to control how the report is handled, including whether or not to pursue a formal investigation. The University's goal is to make sure you are aware of the range of options available to you and to ensure access to the resources you need.

Students wishing to discuss concerns in a confidential setting are encouraged to make an appointment with Counseling and Psychological Services (CAPS).

Students can learn more about filing a report, accessing supportive resources, and navigating the Title IX investigation and resolution process on the University's Title IX webpage.

Statement on Mental Health and Wellness

Texas A&M University recognizes that mental health and wellness are critical factors that influence a student's academic success and overall wellbeing. Students are encouraged to engage in healthy self-care by utilizing available resources and services on your campus

Students who need someone to talk to can contact Counseling & Psychological Services (CAPS) or call the TAMU Helpline (979-845-2700) from 4:00 p.m. to 8:00 a.m. weekdays and 24 hours on weekends. 24-hour emergency help is also available through the National Suicide Prevention Hotline (800-273-8255) or at suicidepreventionlifeline.org.

COVID-19 Amendment

To help protect Aggieland and stop the spread of COVID-19, Texas A&M University urges students to be vaccinated and to wear masks in classrooms and all other academic facilities on campus, including labs. Doing so exemplifies the Aggie Core Values of respect, leadership, integrity, and selfless service by putting community concerns above individual preferences. COVID-19 vaccines and masking — regardless of vaccination status — have been shown to be safe and effective at reducing spread to others, infection, hospitalization, and death.