

CSC 416/565: Design and Construction of Compilers

CSC416 Fulfills UGRD CSC Major Large-Scale Complex Systems Requirement

Tu, 7:15p – 10p, 25 University Ave. 166

<i>Instructor</i>	Dr. Richard Burns
<i>Office</i>	UNA 150D (25 University Ave.)
<i>Office Hours</i>	[Virtual] Mondays: 1p-3p [In-Person or Virtual] Tuesdays: 4p-5p [In-Person or Virtual] Wednesdays: 12p-1p [In-Person or Virtual] Thursdays: 1p-2p
	Appointments must be booked in advance
<i>Email</i>	rburns at wcupa dot edu 610-436-2690
<i>Phone (don't call, email!)</i>	Email will get a faster response (usually within 24 hours) for questions, appts, etc. Only use the phone for emergencies when you have no access to email (e.g. "I am in Australia and will miss today's exam.")

Course Websites

- **Main Website:** <http://www.cs.wcupa.edu/~rburns/Compilers>
- **Supplemental Course Website:** <https://d2l.wcupa.edu>

Catalog Descriptions

CSC416: Covers the basic topics in compiler design including lexical analysis, syntax analysis, error handling, symbol tables, intermediate code generation, and some optimization. Programming assignments will build various pieces of a compiler for a small language.

CSC565: An in-depth study of the principles and design aspects of programming language translation. Students will design and implement a compiler using standard UNIX-based compiler tools for a small but representative language.

Extended Course Description

Design and construction of compilers including lexical analysis; parsing techniques such as LL(1), LR, and LALR(1) code generation techniques. Error analysis and simple code optimizations will be introduced. A large-scale project consisting of developing a lexical analyzer, parser, abstract syntax tree, symbol table, activation code, and intermediate code generation, and finally generating assembly code will be implemented. Students will design and implement a compiler using standard UNIX-based compiler tools for a small but representative language.

CSC416 Prerequisites: CSC220, CSC240, CSC241, {CSC231 or CSC242}

CSC565 Prerequisites: CSC520, CSC530

Credits: 3

Required Materials

Textbook (free e-book): Douglas Thain, *Introduction to Compilers and Language Design*, 2nd edition, 2020. <http://compilerbook.org/>

Hardware: We will utilize the West Chester University CS laboratories throughout the semester. Credentials will be provided to you.

Software: We will utilize the Java programming language and various tools throughout the semester. All software will either be free to download or provided to you.

Course Student Learning Outcomes

By the end of the course, students should be able to:

- (SLO1): understand the phases of a compiler.
- (SLO2): utilize modern tools to perform the lexing and parsing phases of a compiler's front-end.
- (SLO3): understand the theoretical concepts of LL(1) and LR(1) parsing.
- (SLO4): understand the back-end phases of a compiler, including: intermediate representations, runtime organization, optimization, and code generation.
- (SLO5): implement a compiler that spans from the lexical front-end to code generation in the back-end.

Meeting and Assessing Student Learning Outcomes

Student learning outcomes will be assessed via programming assignments, in-class examinations, and out-of-class written homeworks.

CS Program Objectives	CS / ABET Program Outcomes	Course Level Student Learning Outcome	Assessment
<i>Objective 1:</i> Our graduates will be able to apply theory, techniques, and methodologies to	<i>Outcome 2:</i> Design, implement, and evaluate a computing-based solution to meet a	SLO2 SLO4 SLO5	Programming Assignments

create and/or maintain high quality computing systems that function effectively and reliably in the emerging and future information infrastructure.	given set of computing requirements in the context of the program's discipline.	SLO1 SLO3 SLO4	Exams
		SLO1 SLO3 SLO4	Written Homeworks

Grading & Assignments

At the end of the semester, your final grade will be determined by using the following calculation:

Total	=	30%	x	the equally weighted average of all programming assignments
	+	20%	x	the equally weighted average of all written homeworks
	+	20%		midterm exam
	+	30%		final exam
Final Letter	=	the letter matching your Total in the below performance table (<i>decimal grades equal or above .5 will be rounded up, e.g. 89.6 → 90</i>)		

Number of assignments: There will be approximately 2-3 written homeworks, 5-6 programming assignments, one midterm exam, and one final exam.

The final letter grade will be assigned course according to the following scale:

Grade	Quality Points	CSC416		CSC565	
		Percentage Equivalents	Interpretation	Percentage Equivalents	Interpretation
A	4.00	93-100	Excellent	93-100	Superior graduate attainment
A-	3.67	90-92		90-92	
B+	3.33	87-89	Superior	87-89	Satisfactory graduate attainment
B	3.00	83-86		83-86	
B-	2.67	80-82		80-82	
C+	2.33	77-79	Average	77-79	Attainment below graduate expectations
C	2.00	73-76		73-76	
C-	1.67	70-72		70-72	
D+	1.33	67-69	Below Average		
D	1.00	63-66			

D-	0.67	60-62			
F	0	< 60%	Failure	< 70%	Failure

CSC416: Refer to the Undergraduate Catalog for description of NG (No Grade), W, Z, and other grades.

CSC565: D grades are not used. Refer to the Graduate Catalog for description of NG (No Grade), W, & other grades.

Lateness Policy

Assignments that are late are assessed a 10% per day late penalty. Saturday and Sunday are each days.

Tentative Course Outline

Warning to Students! This is a challenging class. If you do not have the time or energy to dedicate to performing the work for this class, you should not enroll. The requirements for this class will not be reduced no matter how much other work you encounter in other classes that you may be enrolled in.

The course schedule is posted on the course webpage. The schedule is tentative and is subject to change.

This list outlines the topics that we will study in the course and may be modified as the semester progresses:

1. Course Introduction; Compiler Overview
2. Data Structures for Tree Languages
3. Lexical Tokens
4. Regular Languages
5. Finite Automata
6. Converting Regexs into DFAs
7. Parse Trees and Derivations
8. Top-Down Parsing
9. Eliminating Left Recursion
10. Left Factoring
11. LL(1) Parsing Tables
12. Bottom-Up Parsing
13. Parsing Tools and Error Recovery
14. Abstract Syntax Trees
15. Visitor Design Pattern
16. Semantic Actions
17. Disambiguating Grammars
18. Symbol Tables

19. Type Checking
20. Frame Layouts
21. Runtime Organization
22. MIPS
23. Code Generation
24. Local Optimization
25. Global Optimization
26. Register Allocation

Quick cross-reference links to below sections:

- [Undergraduate University Policies](#)
- [Graduate University Policies](#)
- [Additional Course Policies](#)

University Policies

Undergraduate University Policies

The below sections contains statements that are common to all **WCU undergraduate syllabi**.

Academic & Personal Integrity

It is the responsibility of each student to adhere to the university's standards for academic integrity. Violations of academic integrity include any act that violates the rights of another student in academic work, that involves misrepresentation of your own work, or that disrupts the instruction of the course. Other violations include (but are not limited to): cheating on assignments or examinations; plagiarizing, which means copying any part of another's work and/or using ideas of another and presenting them as one's own without giving proper credit to the source; selling, purchasing, or exchanging of term papers; falsifying of information; and using your own work from one class to fulfill the assignment for another class without significant modification. Proof of academic misconduct can result in the automatic failure and removal from this course. For questions regarding Academic Integrity, the No-Grade Policy, Sexual Harassment, or the Student Code of Conduct, students are encouraged to refer to the Department Undergraduate Handbook, the Undergraduate Catalog, the Ram's Eye View, and the University website at www.wcupa.edu.

Accommodations for Students With Disabilities

West Chester University is committed to providing equitable access to the full WCU experience for Golden Rams of all abilities. Students should contact the Office of Educational Accessibility (OEA) to establish accommodations if they have had accommodations in the past or if they believe they may be eligible for accommodations due to a disability, whether or not it may be readily apparent. There is no deadline for disclosing to OEA or for requesting to use approved accommodations in a given course. However, accommodations can only be applied to future assignments or exams; that is, they can't be applied retroactively. Please share your letter from

OEA as soon as possible so that we can discuss accommodations. If you have concerns related to disability discrimination, please contact the university's ADA Coordinator in the Office of Diversity, Equity, and Inclusion: <https://www.wcupa.edu/admin/diversityEquityInclusion/> or 610-436-2433.

Excused Absences Policy

Students are advised to carefully read and comply with the excused absences policy, including absences for university-sanctioned events, contained in the WCU Undergraduate Catalog. In particular, please note that the "responsibility for meeting academic requirements rests with the student," that this policy does not excuse students from completing required academic work, and that professors can require a "fair alternative" to attendance on those days that students must be absent from class in order to participate in a University-Sanctioned Event.

Reporting Incidents Of Sexual Violence

West Chester University and its faculty are committed to assuring a safe and productive educational environment for all students. In order to comply with the requirements of Title IX of the Education Amendments of 1972 and the University's commitment to offering supportive measures in accordance with the new regulations issued under Title IX, the University requires faculty members to report incidents of sexual violence shared by students to the University's Title IX Coordinator. The only exceptions to the faculty member's reporting obligation are when incidents of sexual violence are communicated by a student during a classroom discussion, in a writing assignment for a class, or as part of a University-approved research project. **Faculty members are obligated to report sexual violence or any other abuse of a student who was, or is, a child (a person under 18 years of age) when the abuse allegedly occurred to the person designated in the University Protection of Minors Policy.** Information regarding the reporting of sexual violence and the resources that are available to victims of sexual violence is set forth at: <https://www.wcupa.edu/admin/diversityEquityInclusion/sexualMisconduct/default.aspx>

Inclusive Learning Environment and Anti-Racist Statement

Diversity, equity, and inclusion are central to West Chester University's mission as reflected in our [Mission Statement](#), [Values Statement](#), [Vision Statement](#) and [Strategic Plan: Pathways to Student Success](#). We disavow racism and all actions that silence, threaten, or degrade historically marginalized groups in the U.S. We acknowledge that all members of this learning community may experience harm stemming from forms of oppression including but not limited to classism, ableism, heterosexism, sexism, Islamophobia, anti-Semitism, and xenophobia, and recognize that these forms of oppression are compounded by racism. Our core commitment as an institution of higher education shapes our expectation for behavior within this learning community, which represents diverse individual beliefs, backgrounds, and experiences. Courteous and respectful behavior, interactions, and responses are expected from all members of the University. We must work together to make this a safe and productive learning environment for everyone. Part of this work is recognizing how race and other aspects of who we are shape our beliefs and our experiences as individuals. It is not enough to condemn acts of racism. For real, sustainable change, we must stand together as a diverse

coalition against racism and oppression of any form, anywhere, at any time. Resources for education and action are available through WCU's [Office for Diversity, Equity, and Inclusion](#) (ODEI), DEI committees within departments or colleges, the student [ombudsperson](#), and centers on campus committed to doing this work (e.g., [Dowdy Multicultural Center](#), [Center for Women and Gender Equity](#), and the [Center for Trans and Queer Advocacy](#)). Guidance on how to report incidents of discrimination and harassment is available at the University's [Office of Diversity, Equity and Inclusion](#).

Emergency Preparedness

All students are encouraged to sign up for the University's free WCU ALERT service, which delivers official WCU emergency text messages directly to your cell phone. For more information, visit www.wcupa.edu/wcualert. To report an emergency, call the Department of Public Safety at 610-436-3311.

Electronic Mail Policy

It is expected that faculty, staff, and students activate and maintain regular access to University provided e-mail accounts. Official university communications, including those from your instructor, will be sent through your university e-mail account. You are responsible for accessing that mail to be sure to obtain official University communications. Failure to access will not exempt individuals from the responsibilities associated with this course.

Graduate University Policies

The below sections contains statements that are common to all **WCU graduate syllabi**.

Academic & personal integrity

It is the responsibility of each student to adhere to the university's standards for academic integrity. Violations of academic integrity include any act that violates the rights of another student in academic work, that involves misrepresentation of your own work, or that disrupts the instruction of the course. Other violations include (but are not limited to): cheating on assignments or examinations; plagiarizing, which means copying any part of another's work and/or using ideas of another and presenting them as one's own without giving proper credit to the source; selling, purchasing, or exchanging of term papers; falsifying of information; and using your own work from one class to fulfill the assignment for another class without significant modification. Proof of academic misconduct can result in the automatic failure and removal from this course. For questions regarding Academic Integrity, the No-Grade Policy, Sexual Harassment, or the Student Code of Conduct, students are encouraged to refer to the Department Graduate Handbook, the Graduate Catalog, the Ram's Eye View, and the University website at www.wcupa.edu.

Accommodations for students with disabilities

West Chester University is committed to providing equitable access to the full WCU experience for Golden Rams of all abilities. Students should contact the Office of Educational Accessibility

(OEA) to establish accommodations if they have had accommodations in the past or if they believe they may be eligible for accommodations due to a disability, whether or not it may be readily apparent. There is no deadline for disclosing to OEA or for requesting to use approved accommodations in a given course. However, accommodations can only be applied to future assignments or exams; that is, they can't be applied retroactively. Please share your letter from OEA as soon as possible so that we can discuss accommodations.

If you have concerns related to disability discrimination, please contact the university's ADA Coordinator in the Office of Diversity, Equity, and Inclusion:

<https://www.wcupa.edu/admin/diversityEquityInclusion/> or 610-436-2433.

Excused absences policy

Students are advised to carefully read and comply with the excused absences policy, including absences for university-sanctioned events, contained in the WCU Graduate Catalog. In particular, please note that the "responsibility for meeting academic requirements rests with the student," that this policy does not excuse students from completing required academic work, and that professors can require a "fair alternative" to attendance on those days that students must be absent from class in order to participate in a University-Sanctioned Event.

Reporting incidents of sexual violence

West Chester University and its faculty are committed to assuring a safe and productive educational environment for all students. In order to comply with the requirements of Title IX of the Education Amendments of 1972 and the University's commitment to offering supportive measures in accordance with the new regulations issued under Title IX, the University requires faculty members to report incidents of sexual violence shared by students to the University's Title IX Coordinator. The only exceptions to the faculty member's reporting obligation are when incidents of sexual violence are communicated by a student during a classroom discussion, in a writing assignment for a class, or as part of a University-approved research project. **Faculty members are obligated to report sexual violence or any other abuse of a student who was, or is, a child (a person under 18 years of age) when the abuse allegedly occurred to the person designated in the University Protection of Minors Policy.** Information regarding the reporting of sexual violence and the resources that are available to victims of sexual violence is set forth at: <https://www.wcupa.edu/admin/diversityEquityInclusion/sexualMisconduct/default.aspx>

Inclusive Learning Environment and Anti-Racist Statement

Diversity, equity, and inclusion are central to West Chester University's mission as reflected in our [Mission Statement](#), [Values Statement](#), [Vision Statement](#) and [Strategic Plan: Pathways to Student Success](#). We disavow racism and all actions that silence, threaten, or degrade historically marginalized groups in the U.S. We acknowledge that all members of this learning community may experience harm stemming from forms of oppression including but not limited to classism, ableism, heterosexism, sexism, Islamophobia, anti-Semitism, and xenophobia, and recognize that these forms of oppression are compounded by racism.

Our core commitment as an institution of higher education shapes our expectation for behavior within this learning community, which represents diverse individual beliefs, backgrounds, and

experiences. Courteous and respectful behavior, interactions, and responses are expected from all members of the University. We must work together to make this a safe and productive learning environment for everyone. Part of this work is recognizing how race and other aspects of who we are shape our beliefs and our experiences as individuals. It is not enough to condemn acts of racism. For real, sustainable change, we must stand together as a diverse coalition against racism and oppression of any form, anywhere, at any time.

Resources for education and action are available through WCU's [Office for Diversity, Equity, and Inclusion](#) (ODEI), DEI committees within departments or colleges, the student [ombudsperson](#), and centers on campus committed to doing this work (e.g., [Dowdy Multicultural Center](#), [Center for Women and Gender Equity](#), and the [Center for Trans and Queer Advocacy](#)).

Guidance on how to report incidents of discrimination and harassment is available at the University's [Office of Diversity, Equity and Inclusion](#).

Emergency preparedness

All students are encouraged to sign up for the University's free WCU ALERT service, which delivers official WCU emergency text messages directly to your cell phone. For more information, visit www.wcupa.edu/wcualert. To report an emergency, call the Department of Public Safety at 610-436-3311.

Electronic mail policy

It is expected that faculty, staff, and students activate and maintain regular access to University provided e-mail accounts. Official university communications, including those from your instructor, will be sent through your university e-mail account. You are responsible for accessing that mail to be sure to obtain official University communications. Failure to access will not exempt individuals from the responsibilities associated with this course.

Additional Course Policies

This section contains additional policies for the course.

Lateness Policy

Please refer to the "Grading & Assignments" section earlier in this syllabus.

Phone Policy

Your phone should never ring during class, nor should you ever text. Turn your phone on silent before class begins, not on low or vibrate. It is distracting to your classmates. If you choose to answer your phone during class, you will lose 5% off of your final average. *If you have an emergency situation, please discuss it with me in advance.* Phones are not permitted to be out during exams. If your phone is taken out during an exam, you will receive a 0 for the exam.

Attendance Policy (Supplemental to University Attendance Policy)

You are allocated **two** *unexcused* absences. Each class that you miss thereafter due to an unexcused absence is one point off your final grade. Being late twice is the same as one absence. Sleeping in class is the same as being absent. If you miss a class, you are responsible for getting the notes from one of your classmates.

Absences due to serious illness or family emergencies will be considered *excused*, and will not impact your attendance grade. Be sure to email me and provide documentation. Being in jail, having to go to court to avoid jail, family vacations, etc. are not excusable absences. I reserve the right to determine what is “excused” versus “unexcused”.

Attendance Relating to University Sanctioned Events Policy (Supplemental to University Sanctioned Events Policy)

Students participating in participating in university sanctioned events such as, but not limited to, the Marching Band, musical ensembles, theatre group, athletic events, forensics competition, etc., will be granted an excused absence for class periods missed. Students will be granted the privilege of taking, at an alternative time to be determined by the professor, scheduled examinations or quizzes that will be missed. I will designate such times prior to the event and reserve the right to provide a fair alternative to taking the examination or quiz that will be missed. Students must submit original documentation on university letterhead signed by the activity director, coach, or adviser detailing the specifics of the event in advance. Specific requirements include:

- a. Responsibility for meeting academic requirements rests with the student.
- b. Students are expected to notify their professors as soon as they know they will be missing class due to a university sanctioned event.
- c. Students are expected to complete the work requirement for each class and turn in assignments due on days of the event prior to their due dates unless other arrangements are made with myself.
- d. If a scheduled event is postponed or canceled, the student is expected to go to class.
- e. Students are not excused from classes for practice on nonevent days.

The following are specifics for the student athlete:

- a. The student athlete is expected, where possible, to schedule classes on days and at hours that do not conflict with athletic schedules.
- b. Athletes are not excused from classes for practice or training-room treatment on nongame days.

Email Policy (Supplemental to University Email and D2L Policy)

Please abide by the following email etiquette policies to ensure clear communication:

Subject Line:	Please include a descriptive and specific subject heading for all of your emails, including course and section number (e.g. “CSC 050-23: Question about lab 1”).
----------------------	--

Greeting:	Please make a clear and appropriate greeting; I will not answer emails addressed to “hey” or “yo”. Please address me as Dr. Burns or simply Dr. B, or “Professor”.
Tone & Style:	Always use a tone and language that is appropriate to an academic setting; I will not respond to emails that are written in short-hand or without proper punctuation and grammar. Your emails should not resemble a text message.
Sign and Proofread:	Always sign your full name, especially if you are writing from your smart phone. Always proofread your emails before sending.
Email Account:	I will use myWCU and D2L to send out emails to the entire class. It is your responsibility to make sure this is configured correctly so that you receive my emails.

Dishonesty Policy – Supplemental to University Academic & Personal Integrity Policy

The following policies pertain to academic dishonesty:

You must exemplify academic integrity in your work. The following incidents of academic dishonesty violate this integrity:

- Working with another person without permission of the instructor
- Authoring or submitting work for another person, or vice versa, without permission of the instructor
- Reusing work from another semester, course, or section without permission of the instructor
- Distributing your work to another person, or soliciting or accessing another person's work, without permission of the instructor
- Misrepresenting your identity, the authorship of your work, or your activities in the course
- Plagiarism, or using the work of another person without proper attribution

A student found to be academically dishonest in an assignment will receive zero for that assignment if it is his/her first offense in that class [the course, not the class period], but an **F** for the course if it is for his/her second offense in that class [the course]. A student found to be academically dishonest in a test will receive the grade of **F** in that class [the course]. For the purposes of this document on academic dishonesty, every form or method of evaluation in a class will be considered as being of one of two types: an *assignment* or a *test*. Assignments include homework assignments, and short quizzes [and labs]. Tests include final exams and major exams. The instructor has, subject to these guidelines, the discretion to determine the type of any other form of evaluation, such as a project, in his/her class.

If you commit one or more incidents of academic integrity, the instructor will file an Academic Integrity Violation Report to the Office of the Deputy Provost.