Carnegie Mellon University
Master of
Software Engineering

17-614/714: Formal Methods
MW 9:30-10:50 am, 3SC 265 + Remote
A1, Fall 2025, 6 Units

Instructor	Email	Office Location & Hours
Prof. David Garlan	garlan@cs.cmu.edu	TCS 420, by appointment
Prof. Eunsuk Kang	eunsukk@andrew	TCS 322, by appointment

Course Description. Scientific foundations for software engineering depend on the use of precise, abstract models and logics for characterizing and reasoning about properties of software systems. A number of basic models and logics over time have proven to be particularly important and pervasive in the development of software systems. This course is concerned with that body of knowledge. It considers many of the standard models for representing sequential and concurrent systems, such as state machines, relational models, algebras and traces. It shows how you can use different logics to specify properties of software systems, such as functional correctness, deadlock freedom, and internal consistency. Concepts such as composition mechanisms, abstraction relations, invariants, non-determinism, and inductive and denotational descriptions are recurrent themes throughout the course.

Prior Knowledge. Basic discrete mathematics.

Learning Objectives. After completing this course, you should be able to understand the strengths and weaknesses of certain models and logics, including state machines, relational models, algebraic and trace models. You should be able to apply this understanding to select and describe abstract formal models for certain classes of systems. Further, you should be able to reason formally about the certain properties of modeled systems and use associated tools to analyze these systems.

Learning Resources. The following textbooks are required for this course:

- **Models of Software Systems,** by Davd Garlan, Jeannette Wing, and Orieta Celiku. Available on Canvas.
- **Concurrency: State Models and Java Programs,** Second Edition, by Jeff Magee and Jeff Kramer. Wiley, 2006.
- **Software Abstractions: Logic, Language, and Analysis,** Revised Edition, by Daniel Jackson. MIT Press, 2011.

Use of Zoom in the Class. In our class, we will be using Zoom for those students attending remotely. The link is available on Canvas. Please make sure that your Internet connection and

equipment are set up to use Zoom and you are able to share audio and video during class meetings. (See this page for Computing Resources for information on the technology you are likely to need.) Let us know if there is a gap in your technology set-up (garlan@cs.cmu.edu) as soon as possible, and we can see about finding solutions.

Turning on your video: In this course, being able to see one another helps to facilitate a better learning environment and promote more engaging discussions. Therefore, our default will be to *expect students to have their cameras on during lectures and discussions.* However, we also completely understand there may be reasons students would not want to have their cameras on. If you have any concerns about sharing your video, please email us as soon as possible (garlan@cs.cmu.edu) and we can discuss possible adjustments. Note: You may use a background image in your video if you wish; just check in advance that this works with your device(s) and internet bandwidth.

Technical Difficulties: From time to time, we all experience unstable internet connections, unstable computers, etc. In those cases, you may find it necessary to turn your camera off. If you experience technical difficulties during class, please let us know via private chat in Zoom prior to turning your camera off. If technical difficulties are a recurring issue, please reach out to your HUB liaison who will help you access the appropriate resources.

During our class meetings, please keep your microphone muted unless you are sharing with the class or your breakout group.

If you have a question or want to answer a question, please use the chat or the "raise hand" feature. One of the TAs will be monitoring these channels in order to call on students to contribute.

Assessments. Students learn more by applying and explaining ideas to others, thus, the course requires the following activities:

- **Weekly homework assignments**
- **Weekly quizzes**
- **Final in-person exam**
- **Class participation and effort,** to enrich the discussion with your insight, relevant experience, critical questions, and analysis of the material. The quality of contribution is more important than the quantity. This category of assessment also includes completion of extra credit homework, effective use of office hours, attendance, and timely submission of homework.

Course and Grading Policies

- **Late-work policy**: All work is expected to be handed in at the indicated due date and time. In the first week of classes, you should receive a course schedule for each course; please use them to plan ahead in order to meet the submission deadlines for this course.

  Late submissions will be penalized: details of the penalties are available on the course website.

- **Participation policy**. Class participation will be graded by in-class engagement, including asking relevant questions based on a critical review of required readings, lectures, and comments made by your peers. The lack of attendance, and the use of mobile devices — including phones, tablets, and laptops — for purposes other than participating in class, will count against your participation grade.

  This semester involves regular use of technology during class — both for in-person and remote students. Research has shown that divided attention is detrimental to learning; we encourage you to close any windows not directly related to what we are doing while you are in class. Please turn off your phone notifications and limit other likely sources of technology disruption, so that you can fully engage with the material, each other, and me. This will create a better learning environment for everyone.

Attendance. Within the first week of our course, please look ahead and determine if you need to miss class for any excusable reason (religious observance, job interview, university-sanctioned event, etc.) and notify us as soon as possible. You will be expected to attend all class sessions (unless otherwise discussed with the instructor); the instructor or TA will record attendance. Additionally, you will be expected to participate fully in all in-class discussions, exercises, and case studies. Make meaningful contributions when and where you can. Please note that we expect that you will abide by all behaviors indicated in The Word, including any timely updates based on current conditions.

Attendance at conferences and recruiting events. Attendance at conferences and recruiting events, such as the Grace Hopper Celebration, does not relieve you of the responsibility to turn in required homework and quizzes on time. No homework or quiz extensions will be given for these events.

Course Schedule. The following schedule provides a general overview of topics and assignments. Please refer to the syllabus online in Canvas for specific lecture topics, reading assignments and due dates.

#	Date	Subtopic	Reading	Due
Lec 1	M 08/25	Course Overview What is a model?	**Ch 1-3**; N+15	
Lec 2	W 08/27	Propositional & Predicate Logic	**Ch 4, 5**	HW 1: Formal Languages
Rec 1	F 08/29	Logic Exercises		
Lec 3	W 09/03	Proof Techniques	**Ch 4, 5**	HW 2: Logic
Rec 2	F 09/05	Proof Exercises		
Lec 4	M 09/08	State Machine Basics	**Ch 8, 9**	HW 3: Proofs
Lec 5	W 09/10	Reasoning about State Machines	**Ch 10**	
Rec 3	F 09/12	State Machine Exercises		
Lec 6	M 09/15	Object Modeling		HW 4: State Machines
Lec 7	W 09/17	Alloy Part 1: Relational Modeling	Jac11 Ch 1, CACM article on Alloy	
Rec 4	F 09/19	Alloy Exercises		
Lec 8	M 09/22	Concurrency and FSP		HW 5: Alloy
Lec 9	W 09/24	Reasoning about Concurrency Part 1	MK06 Ch 1-5	
Rec 5	F 09/26	FSP Exercises		
Lec 10	M 09/29	Reasoning about Concurrency Part 2	MK06 Ch 6,7	HW 6: Concurrency
Lec 11	W 10/01	Alloy Part 2: Analysis	Jac11, Ch 2	

Rec 6	F 10/03	Alloy and FSP Exercises		
Lec 12	M 10/06	Applications		Project
Lec 13	W 10/08	Applications and Review	SG03 Skim	
Rec 7	F 10/10	Exam Review		

Accommodations for Students Disabilities. If you have a disability and have an accommodations letter from the Disability Resources office, we encourage you to discuss your accommodations and needs with us as early in the semester as possible. We will work with you to ensure that accommodations are provided as appropriate. If you suspect that you may have a disability and would benefit from accommodations but are not yet registered with the Office of Disability Resources, we encourage you to contact them at access@andrew.cmu.edu.

Academic Integrity. Honesty and transparency are important to good scholarship. Plagiarism and cheating, however, are serious academic offenses with serious consequences. If you are discovered engaging in either behavior in this course, you will earn a failing grade on the assignment in question, and further disciplinary action may be taken.

For a clear description of what counts as plagiarism, cheating, and/or the use of unauthorized sources, please see the University's Policy on Academic Integrity.

If you have questions regarding plagiarism or cheating, please ask us as soon as possible to avoid any misunderstandings. For more information about Carnegie Mellon's standards with respect to academic integrity, you can also check out the Office of Community Standards & Integrity website.

Generative AI Tools and Academic Integrity. The use of AI tools, such as ChatGPT, DALL-E 2, and GitHub Copilot, is permitted on homework *provided you note clearly that your solution was generated in whole or in part by that tool*. No AI tools will be permitted during the course's final exam. Note also, that your mastery of the concepts and skills of the course require hands-on practice: short circuiting this through AI tools will likely deprive you of that experience and negatively impact what you learn in the course.

Student Well-Being. We are all under a lot of stress and uncertainty at this time. Attending Zoom classes all day can take its toll on our mental health. Make sure to move regularly, eat

well, and reach out to your support system or us (garlan@cs.cmu.edu) if you need to. We can all benefit from support in times of stress, and this semester is no exception.

As a student, you may experience a range of challenges that can interfere with learning, such as strained relationships, increased anxiety, substance use, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may diminish your academic performance and/or reduce your ability to participate in daily activities. CMU services are available, and treatment does work. You can learn more about confidential mental health services available on campus at the Counseling and Psychological Services website. Support is always available (24/7) from Counseling and Psychological Services: 412-268-2922.

If you are worried about affording food or feeling insecure about food, there are resources on campus who can help. Email (cmu-pantry@andrew.cmu.edu) or call (412-268-8704) the CMU Food Pantry Coordinator to schedule an appointment.

We must treat every individual with respect. We are diverse in many ways, and this diversity is fundamental to building and maintaining an equitable and inclusive campus community. Diversity can refer to multiple ways that we identify ourselves, including but not limited to race, color, national origin, language, sex, disability, age, sexual orientation, gender identity, religion, creed, ancestry, belief, veteran status, or genetic information. Each of these diverse identities, along with many others not mentioned here, shape the perspectives our students, faculty, and staff bring to our campus. We, at CMU, will work to promote diversity, equity, and inclusion not only because diversity fuels excellence and innovation, but because we want to pursue justice. We acknowledge our imperfections while we also fully commit to the work, inside and outside of our classrooms, of building and sustaining a campus community that increasingly embraces these core values.

Each of us is responsible for creating a safer, more inclusive environment.

Unfortunately, incidents of bias or discrimination do occur, whether intentional or unintentional. They contribute to creating an unwelcoming environment for individuals and groups at the university. Therefore, the university encourages anyone who experiences or observes unfair or hostile treatment on the basis of identity to speak out for justice and support, within the moment of the incident or after the incident has passed. Anyone can share these experiences using the following resources:

- **Center for Student Diversity and Inclusion**: csdi@andrew.cmu.edu, (412) 268-2150
- **Ethics Reporting Hotline.** Students, faculty, and staff can anonymously file a report by calling 844-587-0793 or visiting **cmu.ethicspoint.com.**

All reports will be documented and deliberated to determine if there should be any following actions. Regardless of incident type, the university will use all shared experiences to transform our campus climate to be more equitable and just.