Carnegie Mellon University
Master of
Software Engineering

17-614/714: Formal Methods
MW 10:00-11:50 am, 3SC 265 + Remote
TR 10:00-11:50 am, 3SC 265
A1, Fall 2021, 6 Units

Instructor	Email	Office Location & Hours
Prof. David Garlan	dg4d@andrew.cmu.cmu	TCS 420, by appointment
Prof. Eunsuk Kang	eunsukk@andrew.cmu.edu	TCS 322, by appointment

Teaching Assistants

Simon Chu	cchu2@andrew.cmu.edu	Zoom, M 7-8 pm EST
Jiahua Huang	jiahuah@andrew.cmu.edu	3SC 266, F 4:30-5:30 pm EST
Yizhang Miao	yizhangm@andrew.cmu.edu	Zoom, F 7-8 pm EST
Paul Wei	yaowei@andrew.cmu.edu	3SC 266, W 4:30-5:30 pm EST

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 (eunsukk@andrew.cmu.edu) as soon as possible, and we can see about finding solutions.

Sharing 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, I 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 (eunsukk@andrew.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 me 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 mic 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 (available when the participant list is pulled up). 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**
- **Team project**
- **Final take-home exam**
- **Class participation**

Assessment	Final Grade %
Homework	30%
Quizzes	10%
Project	30%
Exam	30%

Grade	Percentage Interval
A	90-100%
B	80-89%
C	70-79%
D	60-69%
R (F)	59% or below

Course and Grading Policies

- **Late-work policy**: All work is expected to be handed in at the indicated due date and time. For fairness to the whole class, no late submissions will be accepted for the group work. In the first week of classes, you should receive a course schedule for each course; please use them to plan ahead.

  Each student is allowed one late submission for the individual homework assignments. You should immediately notify the course TA(s) before the submission deadline that you will submit late. Late work must be submitted as soon as circumstances allow, ordinarily within 24 hours of the due date. If you have any questions you should raise them immediately rather than waiting for conflicts to arise.

- **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; I 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. For those students scheduled to attend class in person, I expect that you will abide by all behaviors indicated in A Tartan's Responsibility, including any timely updates based on the current conditions.

Facial coverings. If you do not wear a facial covering to class, I will ask you to put one on (and if you don't have one with you, I will direct you to a distribution location on campus). If you do not comply, please remember that you will be subject to student conduct proceedings, up to and including removal from CMU. Accordingly, I will be obliged to take other measures for the safety of the whole class.

Recording of Class Sessions. All synchronous classes will be recorded via Zoom so that students in this course (and only students in the course) can watch or re-watch past class sessions. Please note that breakout rooms will not be recorded. I will make recordings available on Canvas as soon as possible after each class session (usually within 3 hours of the class meeting). Recordings will live on our Canvas website. Please note that you are not allowed to share these recordings. This is to protect your FERPA rights and those of your fellow students.

Transferring to Fully Remove During the Semester. If the class needs to go fully remote, you will receive an email from us and an announcement will be published on our course website on Canvas.

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 08/30	Course Overview What is a model?	**Ch 1-3**; N+15	
Lec 2	W 09/01	Propositional & Predicate Logic	**Ch 4, 5**	HW 1: Formal Languages
Rec 1	F 09/03	Logic Exercises		
Lec 3	W 09/08**	Proof Techniques	**Ch 4, 5**	HW 2: Logic
Rec 2	F 09/10	Proof Exercises		
Lec 4	M 09/13	Sets, Relations, Functions, Sequences	**Ch 6**	HW 3: Proofs
Lec 5	W 09/15	State Machine Basics	**Ch 8, 9**	
Rec 3	F 09/17	State Machine Modeling		
Lec 6	M 09/20	Reasoning about State Machines	**Ch 10**	HW 4: State Machines
Lec 7	W 09/22	Object Modeling		
Rec 4	F 09/24	Invariants		
Lec 8	M 09/27	Introduction to Alloy	Jac11 Ch 1, CACM article on Alloy	HW 5: State Machine Reasoning
Lec 9	W 09/29	Analysis in Alloy	Jac11, Ch 2	
Rec 5	F 10/01	Alloy Exercises		
Lec 10	M 10/04	Concurrency Basics	MK06 Ch 1-5	HW 6: Alloy
Lec 11	W 10/06	Introduction to FSP & LTSA	MK06 Ch 6,7	
Rec 6	F 10/08	FSP Exercises		
Lec 12	M 10/11	Applications of Formal Methods		HW 7: Concurrency

Accommodations for Students Disabilities. If you have a disability and have an accommodations letter from the Disability Resources office, I encourage you to discuss your accommodations and needs with me as early in the semester as possible. I 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, I 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 any questions regarding plagiarism or cheating, please ask me 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.

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 (eunsukk@andrew.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
- **Report-It online anonymous reporting platform**: reportit.net username: *tartans* password: *plaid*

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.