Carnegie Mellon University
Electrical & Computer Engineering

Course Syllabus

18781: *Speech Recognition and Understanding*
Fall 2026

Instructor: Samuele Cornell
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Email Address: scornell@andrew.cmu.edu
Office Hours: Tuesday 2-3pm

Co-Instructor:
Office Location: TBD
Email Address: dd
Office Hours: TBD

Number of Units: 12
Pre-requisites/Prior Knowledge: No course requirements, but it requires a sound mathematical background, knowledge of basic statistics and machine learning, and good computing skills based on Python and Linux.
Class days/times: Monday/Wednesday, 3:30 pm – 4:50 pm, BH A51

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Course Support: Academic Services Center
Office Location: HH 1113
Website: https://www.ece.cmu.edu/academics/academic-services-center.html

Course Description: The technology to allow humans to communicate by speech with machines or by which machines can understand when humans communicate with each other is rapidly maturing. This course is an introduction to automatic speech recognition

(ASR), covering both the theory and the practice that made the field what it is today. On the theory side, we work through the mathematical foundations and core algorithms of the field, from hidden Markov models to modern end-to-end neural networks and conversational AI. On the practical side, you will learn the experimental skills needed to build, train, and evaluate state-of-the-art systems. This course is suitable for graduate students with some background in computer science and electrical engineering, as well as for advanced undergraduates. Prerequisites: Sound mathematical background, knowledge of basic statistics, machine learning, and good computing skills. No prior experience with speech recognition is necessary. This course is primarily for graduate students in LTI, CS, Robotics, ECE, Psychology, or Computational Linguistics. Others by prior permission of instructor.
Graduate Area: Human Language Technology/Machine Learning/Speech Processing/Artificial Intelligence
Brief List of Topics Covered: Introduction to automatic speech recognition, hidden Markov models, language models, end-to-end neural networks, application of deep learning to speech recognition, conversational AI

Course Learning Objectives:

1. Students will be able to explain the mathematical formulations underlying modern speech recognition, including HMM-based, CTC, RNN-transducer, and attention-based end-to-end models.
2. Students will be able to implement core speech recognition algorithms, such as feature extraction, HMM models, and end-to-end neural architectures, in Python.
3. Students will be able to build, train, and evaluate state-of-the-art speech recognition systems, including data preparation and training/inference tuning.
4. Students will be able to design and conduct an original group research project on a core speech recognition problem and communicate the results through written reports and oral presentations.

Learning Resources:
Required Textbook: No required text
Suggested Reading: They will be shown in the lecture material
Reference Materials: They will be shown in the lecture material

Course Canvas/Website:
We will not use Canvas. Instead, we will use the following:

- Piazza: https://piazza.com/cmu/fall2026/1175118781 for the main discussions and course materials
- Gradescope: https://www.gradescope.com/courses/1314409 (Entry Code: PK4V8V) for grading

Course Website: TBD

Assignments/Assessments: We will have around 10 weekly assignments and 4 coding assignments. No reading assignments.
Grading Algorithm:

- Class participation 25%
    - Regular class points: 20
    - ESPnet tutorial: 5
- Assignments 30%
    - Weekly assignments: 10 x 1
    - Coding assignments: 5 x 4
- Mid-term exam 20%
- Term Project 25%

Attendance Policy:

Class participation is assessed through short quizzes released in Piazza during each lecture. There is no separate attendance record, and no quiz submission means no participation point for that class, even if you attend. So, if you participate in the class but cannot submit the quiz, please report it to the TAs or to the instructor as soon as possible. Each of the 22 regular lectures (excluding the ESPnet tutorials, the mid-term exam, and term-project events) is worth 1 point, for 20 points plus a 2-point bonus. Thus, students can miss up to two lectures and still earn the full participation points. A quiz with no answer earns 0%, a correct answer 100%, and an incorrect answer 90%. A non-edited recording of each lecture is released right after class so that you can catch up on the lecture contents if you must be absent. There are no extensions for class participation points, as the two bonus points serve as the buffer. Exceptions can be made in exceptional circumstances.

Academic Integrity Policy:
ECE Academic Integrity Policy
(http://www.ece.cmu.edu/programs-admissions/masters/academic-integrity.html**):**

The Department of Electrical and Computer Engineering adheres to the academic integrity policies set forth by Carnegie Mellon University and by the College of Engineering. ECE students should review fully and carefully Carnegie Mellon University's policies regarding Cheating and Plagiarism; Undergraduate Academic Discipline; and Graduate Academic Discipline. ECE graduate student should further review the Penalties for Graduate Student Academic Integrity Violations in CIT outlined in the CIT Policy on Graduate Student Academic Integrity Violations. In addition to the above university and college-level policies, it is ECE's policy that an ECE graduate student may not drop a course in which a disciplinary action is assessed or pending without the course instructor's explicit approval. Further, an ECE course instructor may set his/her own course-specific academic integrity policies that do not conflict with university and college-level policies; course-specific policies should be made available to the students in writing in the first week of class.

This policy applies, in all respects, to this course.

CMU Academic Integrity Policy (http://www.cmu.edu/academic-integrity/index.html**):**

In the midst of self-exploration, the high demands of a challenging academic environment can create situations where some students have difficulty exercising good judgment. Academic challenges can provide many opportunities for high standards to evolve if students actively reflect on these challenges and if the community supports discussions to aid in this process. It is the responsibility of the entire community to establish and maintain the integrity of our university.

This site is offered as a comprehensive and accessible resource compiling and organizing the multitude of information pertaining to academic integrity that is available from across the university. These pages include practical information concerning policies, protocols and best practices as well as articulations of the institutional values from which the policies and protocols grew. The Carnegie Mellon Code, while not formally an honor code, serves as the foundation of these values and frames the expectations of our community with regard to personal integrity.

This policy applies, in all respects, to this course.

The Carnegie Mellon Code

Students at Carnegie Mellon, because they are members of an academic community dedicated to the achievement of excellence, are expected to meet the highest standards of personal, ethical and moral conduct possible.

These standards require personal integrity, a commitment to honesty without compromise, as well as truth without equivocation and a willingness to place the good of the community above the good of the self. Obligations once undertaken must be met, commitments kept.

As members of the Carnegie Mellon community, individuals are expected to uphold the standards of the community in addition to holding others accountable for said standards. It is rare that the life of a student in an academic community can be so private that it will not affect the community as a whole or that the above standards do not apply.

The discovery, advancement and communication of knowledge are not possible without a commitment to these standards. Creativity cannot exist without acknowledgment of the creativity of others. New knowledge cannot be developed without credit for prior knowledge. Without the ability to trust that these principles will be observed, an academic community cannot exist.

The commitment of its faculty, staff and students to these standards contributes to the high respect in which the Carnegie Mellon degree is held. Students must not destroy that respect by their failure to meet these standards. Students who cannot meet them should voluntarily withdraw from the university.

This policy applies, in all respects, to this course.

Carnegie Mellon University's Policy on Cheating
(http://www.cmu.edu/academic-integrity/cheating/index.html) states the following:

According to the University Policy on Academic Integrity, cheating "occurs when a student avails her/himself of an unfair or disallowed advantage which includes but is not limited to:

- Theft of or unauthorized access to an exam, answer key or other graded work from previous course offerings.
- Use of an alternate, stand-in or proxy during an examination.
- Copying from the examination or work of another person or source.
- Submission or use of falsified data.
- Using false statements to obtain additional time or other accommodation.
- Falsification of academic credentials."

This policy applies, in all respects, to this course.

Carnegie Mellon University's Policy on Plagiarism
(http://www.cmu.edu/academic-integrity/plagiarism/index.html) states the following:

According to the University Policy on Academic Integrity, plagiarism "is defined as the use of work or concepts contributed by other individuals without proper attribution or citation. Unique ideas or materials taken from another source for either written or oral use must be fully acknowledged in academic work to be graded. Examples of sources expected to be referenced include but are not limited to:

- Text, either written or spoken, quoted directly or paraphrased.
- Graphic elements.
- Passages of music, existing either as sound or as notation.
- Mathematical proofs.
- Scientific data.
- Concepts or material derived from the work, published or unpublished, of another person."

This policy applies, in all respects, to this course.

Carnegie Mellon University's Policy on Unauthorized Assistance
(http://www.cmu.edu/academic-integrity/collaboration/index.html) states the following:

According to the University Policy on Academic Integrity, unauthorized assistance "refers to the use of sources of support that have not been specifically authorized in this policy statement or by the course instructor(s) in the completion of academic work to be graded. Such sources of support may include but are not limited to advice or help provided by another individual, published or unpublished written sources, and electronic sources. Examples of unauthorized assistance include but are not limited to:

- Collaboration on any assignment beyond the standards authorized by this policy statement and the course instructor(s).
- Submission of work completed or edited in whole or in part by another person.

- Supplying or communicating unauthorized information or materials, including graded work and answer keys from previous course offerings, in any way to another student.
- Use of unauthorized information or materials, including graded work and answer keys from previous course offerings.
- Use of unauthorized devices.
- Submission for credit of previously completed graded work in a second course without first obtaining permission from the instructor(s) of the second course. In the case of concurrent courses, permission to submit the same work for credit in two courses must be obtained from the instructors of both courses."

This policy applies, in all respects, to this course.

Carnegie Mellon University's Policy on Research Misconduct (http://www.cmu.edu/academic-integrity/research/index.html) states the following:

According to the University Policy for Handling Alleged Misconduct in Research, "Carnegie Mellon University is responsible for the integrity of research conducted at the university. As a community of scholars, in which truth and integrity are fundamental, the university must establish procedures for the investigation of allegations of misconduct of research with due care to protect the rights of those accused, those making the allegations, and the university. Furthermore, federal regulations require the university to have explicit procedures for addressing incidents in which there are allegations of misconduct in research."

The policy goes on to note that "misconduct means:

- fabrication, falsification, plagiarism, or other serious deviation from accepted practices in proposing, carrying out, or reporting results from research;

- material failure to comply with Federal requirements for the protection of researchers, human subjects, or the public or for ensuring the welfare of laboratory animals; or

- failure to meet other material legal requirements governing research."

"To be deemed misconduct for the purposes of this policy, a 'material failure to comply with Federal requirements' or a 'failure to meet other material legal requirements' must be intentional or grossly negligent."

To become familiar with the expectations around the responsible conduct of research, please review the guidelines for Research Ethics published by the Office of Research Integrity and Compliance.

This policy applies, in all respects, to this course.

Policy Regarding Use of Generative AI Tools:
All assignments: students are NOT allowed to use AI tools for creating the answers. Students are allowed to use AI tools for polishing their answers or debugging them.
Term projects: students are encouraged to use AI tools for conducting their research (brainstorming ideas, surveys, data processing, and coding). Students are NOT allowed to use AI tools for creating the reports; they are allowed to use AI tools for polishing the reports.
Term project scope: the project topic must be related to core speech recognition topics. Speech processing tasks involving only segment-wise classification (e.g., emotion recognition) alone will not be sufficient (but students are encouraged to blend them with general speech recognition and understanding). Plain use of commercial APIs or models (e.g., OpenAI Whisper) is not allowed unless it is specified or there is meaningful modification/innovation.
AI-generated content must be appropriately acknowledged and cited, following the guidelines established by the APA Style Guide. It is each student's responsibility to assess the validity and applicability of any AI output that is submitted; you may not earn full credit if inaccurate or invalid information is found in your work. Deviations from the guidelines above will be considered violations of CMU's academic integrity policy.

Policy on Late/Make-up Work:

Students are expected to submit all assignments by the stated deadlines. Unless otherwise specified, deadlines are at 11:59 pm ET. If an assignment cannot be completed on time, students should submit their partial work; partial submissions will be considered for credit, and because several assignments build upon one another, missed material can frequently be recovered at a subsequent deadline. Each student is granted a total of five late days (120 hours) to be applied across all assignments. Late time is tracked on an hourly basis through Gradescope, and no penalty is applied while the late-day allowance remains. Once the allowance has been exhausted, an assignment submitted within five days of its deadline is eligible for at most half of the earned score (e.g., a score of 8.4 points is reduced to 4.2); submissions received thereafter will not be accepted for credit. The late-day allowance does not apply to class participation points or to term-project deadlines. No late submissions are accepted for any component of the term project; class participation is instead governed by the bonus-point provision described in the Attendance Policy. In extenuating circumstances, such as hospitalization or a family emergency, students should notify the instructor at the earliest opportunity; such cases will be evaluated on an individual basis.

Additional Academic Support Resources:
Students are encouraged to avail themselves of the support resources available through the Student Academic Success Center (SASC). Directions for contacting them are available on their website linked above, or via the contact details below.

Phone: (412) 268-6823
Email: success@andrew.cmu.edu
Location: Posner Hall, 1st floor, open Monday through Friday, 8:30 am to 5:00 pm (EDT)

Accommodations for Students with Disabilities:
If you have a disability and require accommodations but do not already have them approved by the Office of Disability Resources, please apply for accommodations through the Application section of the Disability Resources Online Portal. If you already have accommodations approved with Disability Resources, please use the Accommodations Management section of the Disability Resources Online Portal to notify me about your accommodations, and discuss your accommodations and needs with me as early in the semester as possible. We will work with you to ensure that accommodations are provided as appropriate.

Statement encouraging student wellness:
Take care of yourself. Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress.

All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful.

If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit their website at http://www.cmu.edu/counseling/. Consider reaching out to a friend, faculty or family member you trust for help getting connected to the support that can help.

If you have questions about this or your coursework, please let me know.

Inclusive Excellence Statement:
Every individual must be treated with respect. The ways we are diverse are many and are critical to excellence and an inclusive community. They include but are not limited to: race, color, national origin, sex, disability, age, sexual orientation, gender identity, religion, creed, ancestry, belief, veteran status, or genetic information. We at CMU, will work to promote diversity, equity and inclusion because it is just and necessary for innovation. Therefore, while we are imperfect, we will work inside and outside of our classrooms, to increase our commitment to build and sustain a community that embraces these values.

It is the responsibility of each of us to create a safer and more inclusive environment. Bias incidents, whether intentional or unintentional in their occurrence, contribute to creating an unwelcoming environment for individuals and groups at the university. If you experience or observe unfair or hostile treatment on the basis of identity, we encourage you to speak out for justice and support in the moment and and/or share your experience anonymously using the following resources:
Center for Student Diversity and Inclusion: csdi@andrew.cmu.edu, (412) 268-2150, www.cmu.edu/student-diversity

Report-It online anonymous reporting platform: www.reportit.net username**:** *tartans* password**:** *plaid*

All reports will be acknowledged, documented and a determination will be made regarding a course of action." All experiences shared will be used to transform the campus climate.

COURSE OUTCOMES

The ECE Department's BS in ECE is accredited by ABET to ensure the quality of your education. ABET defines 7 Educational Objectives that are fulfilled by the sum total of all the courses you take.

Carnegie Mellon University is accredited by Middlestates to ensure the quality of your education, and asks the department to define Program Learning Outcomes. We have defined 3 major PLOs with sub-bullets for the MS in ECE, plus 1 additional major PLO each for the MS in AIE and for the MS in SE.

Educational Objectives (ABET) or Program Learning Outcomes (Middlestates) represent program-level statements about what students should be able to do upon graduation. The table below maps this course's Course Learning Objectives to the ABET objectives and Middlestates outcomes.

ABET Student Learning Outcomes	**Applicable Course Learning Objective**
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	**#1, #2**
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	**#3, #4**
3. an ability to communicate effectively with a range of audiences	**#4**
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	**#4**
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	**#4**
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	**#3, #4**
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	**#3, #4**
Middlestates Program Learning Outcomes	**Applicable Course Learning Objective**
I. Demonstrate Technical Expertise in a particular area	**#1, #2, #3**

a. By solving problems in which they apply ECE fundamentals *b. By solving complex problems that draw on multiple aspects of ECE* *c. By solving challenging problems that reflect a depth of understanding in ECE*	
II. Demonstrate a spirit of Innovation, Collaboration and Leadership *a. By displaying out of the box thinking in solving current complex problems where there are no existing answers* *b. By successfully collaborating in multidisciplinary teams* *c. By applying holistic systems-oriented thinking to their designs* *d. By participating in research projects*	**#4**
III. Demonstrate professional preparation *a. By engaging in job search and internships* *b. By successfully securing a job as a practicing engineer* *c. By honing professional skills in teamwork, work organization, and oral and written communication*	**#4**
IV Demonstrate AI Technical and Ethical Expertise (MS-AIE Program) *a. By applying artificial intelligence (AI) techniques to solve engineering problems.* *b. By showing an understanding of the theoretical foundations of machine learning and deep learning techniques.* *c. By developing and deploying an AI data flow on the cloud using state-of-the-art tools.* *d. By developing a habit of understanding who may be harmed by AI, and mitigations.*	**#1, #2, #3**
V. Demonstrate Software Engineering Expertise (MS-SE Program) *a. By building software systems through disciplined use of software engineering practices and processes* *b. By ensuring high quality of delivered systems through rigorous testing and analysis techniques* *c. By incorporating the use of professional-grade AI tools across the software development lifecycle* *d. By applying design thinking to build human-centered software systems through understanding needs, ideating solutions, prototyping, and validation.* *e. By conceiving and documenting architectures and designs that follow both novel and proven patterns to produce durable and maintainable systems*	**#3**

Tentative Course Calendar:

	Monday		Wednesday		Friday
8/24	Course introduction	8/26	Introduction of speech recognition		
8/31	Speech recognition formulations	9/2	Feature extraction		
9/7	Labor day	9/9	Acoustic models and alignments		
9/14	Alignment problems	9/16	Hidden Markov Models **Coding assignment 1 release**		
9/21	ESPnet tutorial I	9/23	Forward-backward algorithm for HMM	9/25	
9/28	Guest lecture I Jinchuan Tian (Spoken Language Models)	9/30	ESPnet tutorial II	10/2	**Coding assignment 1 deadline**
10/5	GMM extension and Viterbi algorithm **Coding assignment 2 release** **Project: Topic release**	10/7	Forward-backward algorithm for CTC and Viterbi algorithm	10/9	
Fall break					
10/19	N-gram language model **Project: Team forming and project proposal deadline**	10/21	Search **Coding assignment 3 release**		
10/26	Deep neural network for acoustic modeling **Coding assignment 2 deadline**	10/28	**Mid-term exam**		
11/2	Neural network language model	11/4	End-to-End ASR: Attention **Coding assignment 4 release**	11/6	**Coding assignment 3 deadline**
11/9	End-to-End ASR: CTC	11/11	End-to-End ASR: RNN-T	11/13	**Project: checkpoint**
11/16	Advanced topics on end-to-end ASR I	11/18	Guest lecture II Matthew Wiesner (JHU HLTCOE)	11/20	**Coding assignment 4 deadline**
11/23	Advanced topics on end-to-end ASR II	11/25	Thanksgiving		
11/30	Term project	12/2	Term project presentations	12/4	**Project report**

	presentations I		II		**deadline**