Carnegie Mellon University

14-763/18-763: Systems and Toolchains for AI Engineers

Meeting Dates/Times:
Mon/Wed 3:30PM – 4:50PM ET
Location: CIC 1201 & INI DEC
Course Webpage: https://canvas.cmu.edu/courses/48477

Semester: Fall**, Year:** 2025

Units: 12**, Sections:** A & B

Co-Instructor

Name	Mohamed Farag (he/him) Addressed as “Mohamed” or “Dr. Farag”
Contact Info	farag@cmu.edu
Office Hours Location	CMU Remote
Office Hours	Monday 12-1pm ET and Thursday 4-5PM ET Conducted remotely via Zoom (URL is available on course home page)

Co-Instructor

Name	Guannan Qu (he/him)
Contact Info	gqu@andrew.cmu.edu
Office Hours Location	CMU Remote
Office Hours	Monday 12-1pm ET and Thursday 3-4PM ET (Starting Week-6) Conducted remotely via Zoom (URL is available on course home page)

Course Description

- Adopting Artificial Intelligence in modern era has much more to it than learning the theoretical foundation of AI algorithms. The implementation of Machine Learning and Artificial Intelligence at large-scale requires solid technical infrastructure to support its complex, heavy processes. In this course, students will learn to be effective users of AI systems. Students will gain hands-on experience with modern ML frameworks and infrastructure tools, in the context of large real-world datasets and under conditions requiring engineering design choices. This experience will be gained in conjunction with practical application of class topics on real cloud environment.

- The premise of this course is to build a broad and solid foundation in Artificial Intelligence Infrastructure that will pay significant dividends throughout a student’s research and work career across data science and Artificial Intelligence related fields. In this class, we will focus on the following topics:

    - Data Collection and Storage.
    - Data Streaming.
    - Data Engineering.
    - Modern ML Frameworks.
    - Model Validation and Monitoring.
    - Neural Network Design and Implementation.
    - Embedded Machine Learning.
    - Deployment of ML Models to the Cloud.

- The course material will focus on recent landmark research papers and existing tools and software systems. Students will have substantial programming project work in which they design, implement, and analyze aspects of AI-model infrastructure. This course will use an IoT-relevant dataset throughout the semester. The format of this course will be a mix of lectures and hands-on labs. Students will be responsible for readings, and completing a hands-on project focused on developing applications on Apache Spark, TensorFlow, PyTorch Apache Kafka, PostgreSQL and NoSQL. Readings will be selected from recent conference proceedings and journals.

- **Prerequisites**: Practical experience in Python is highly preferable and exposure to machine learning experience is preferred. Python learning tutorials are offered before the beginning of the class to help the students who need a Python refresher. If you have questions about your programming experience, please let me know at the beginning of the semester, so we can decide how to proceed.

- **Class Structure:** In-class questions are delivered via in-person communication or TopHat, an online course delivery system. TopHat can be accessed on a smartphone or laptop. For this purpose, I will ask you in advance to bring your laptop or mobile device, and we will review how to use the tool together in class. If you do not have the necessary equipment, please contact your HUB liaison who is available to help you tap into appropriate resources. Join code will be posted on Canvas. In addition, lecture materials will be offered via Jupyter Notebooks.

Learning Objectives

In taking and successfully completing this course, students will learn how to, e.g.,

- apply best practices in collecting, storing, and modeling data of various size;
- gain hands-on experience in building and analyzing large-scale AI infrastructure components and developing and testing services that operate within them;
- practice the implementation of large-scale AI algorithms in modern machine-learning frameworks;
- implement data engineering pipelines to streamline the development of complex AI-models;
- understand the benefits of “Productionizing” large complex AI models and deploying them to the Cloud to promote scalability and high availability;
- apply best practices in designing and building neural networks; and
- understand the aspects of building machine learning models for embedded devices

The work that you will carry out in this course maps to some of the learning outcomes that INI has defined as vital to the full CMU graduate-level experience. Specifically:

- self-directed learning;
- critical thinking; and
- complex problem solving.

Learning Resources

There is no primary textbook, as most reading material will come from research papers and other technical documentation. Additional background reading material can be suggested upon request.

Important Dates

- September 1st, 2025: Labor Day (no class/office hours)
- October 13th – October 17th, 2025: Fall break (no classes/office hours).
- November 4th, 2025: Democracy Day (no office hours).
- November 26th– November 28th, 2025: Thanksgiving Break (no class/office hours)
- **December 3rd, 2025: Final exam (during lecture time)**

Assessments

Students are encouraged to attend class regularly, read the assigned reading material and participate in class discussions. The final grade will be based upon 1 exam, 1 project, 8 homework assignments, and in-class quizzes. In-class participation will grant student extra-credit that will help boosting their quiz score.

Final Exam	Project	Assignments	Quizzes
15%	20%	50%	15%

- **Final Exam:** is an open-note test.
  - Students will have access to all the **PDFs for lectures, readings and HW solutions**. Students can **bring any hard-copied materials with them**.
  - Students are required to follow the schedule of their registered section. **On the scheduled final lecture of each section, final exam will be released only to the registered students of the corresponding section**. Each section will have its final exam version(s).
  - **Exam will be offered via Lockdown Browser and no knowledge exchange is allowed among students during the exam.**
  - Students are expected to install and test Lockdown browser on their machines ahead of the exam. If students face an issue with Lockdown browser installation, students must reach out to the instructors **no later than 2 weeks** before the final exam date.
  - **Sharing hard-copied notes is prohibited during the exam.**
- **Quizzes:** are offered during each lecture via Canvas. Each quiz will be accessible via a unique access code that will be provided to students of the corresponding section. Students will have 3-5 minutes to answer 1-2 multiple choice questions.
  - Students enrolled in the remote section will have 24 hours from the end of the lecture to complete the quiz. Please note that no extensions will be offered, so students are encouraged to set reminders in their schedules.
- **Assignments:** will provide the opportunity to practice the concepts that are taught during the class. Students are expected to spend a good amount of time on their own learning implementation details that are not provided during the lectures. Students will receive 8 homework assignments throughout the semester. Homework release schedule is shown on the last section of this syllabus.
- **Project**: details are released in week 3. Each student will have the option to team up with another student for the project and you will choose one of two project options to submit. Students will be expected to record a video including a code-walkthrough of their work and functionality demo showing the running version of their application. Project submission deadline is **November 13th, 2025, 11:59PM ET.** Course project is solely student work. There will be a lot of self-learning that is needed from the students to complete the project. The course instructor will provide project-related hints, high-level directions, and clarifications during

the lectures. However, students shouldn't expect any additional project support during office hours or via email. Students are highly encouraged to give themselves enough time to learn the skills they need to complete the project. There will be one checkpoint to ensure that students are making good continuous progress (Refer to the proposed course schedule in the last section of this syllabus). Project grading rubric and evaluation will be released along with project details.

Students will be assigned the following final letter grades, based on rubric provided in the above table. +/- will be assigned to provide further granularity.

Letter Grade	Percentage Interval
A / A-	[85-100%] – A to start from 93
B	[70-85%)
C	[55-70%)
D	[40-55%)
R (F)	Below 40%

Homework & Project Submission and Grading Policies

- Students are expected to check the course webpage on canvas regularly for announcements, class schedules, lecture notes, homework assignments, reading assignments, and other related course material.
- Starting with HW-2, all homework must be submitted to **Gradescope** as a **GitHub Organization repository link**. To prepare, create a free GitHub account (if you don't already have one) and use the provided GitHub assignment invitation link. This will automatically generate your repository within our course's GitHub Organization, which you will then submit on Gradescope.
- Students are expected to use Google Cloud Platform for homework and project assignments. If students run out of credit (or mis-redeem a coupon), students are requested to email the course instructors.
    - Students should expect a 24–48-hour delay to receive a new coupon.
- Homework and Project assignments must be turned in prior to their specified deadline. Typically, homework is **due one week** after it is assigned unless otherwise mentioned.
- Students are strongly encouraged to complete the assignments as early as they can. No homework extensions will be offered due to technical difficulties.
- **Students will have 3 days to submit an assignment after the due date** and a late penalty will be applied. Late penalties are applied based on the timestamp of the last code commit on GitHub and it will follow this equation:
    - 5 points for delay up to 24 hours (You will get TA support at specific time slots on Zoom and Piazza)
    - 15 points for the next 24-hour delay (You will get TA support at specific time slots on Piazza only)
    - 25 points for the next 24-hour delay (No TA support is provided).
    - 100 points penalty (no grade) after this time.
- **Late submissions for the course project will receive no grade (0 points).**
- After homework and project grades are released, **regrade requests may be submitted through Gradescope only within 24 hours**. Requests submitted via email will not be accepted, and no regrade requests will be considered once the 24-hour window has closed.
- For grading clarification, email the TA or ask your question during TA office hours. If you continue to have an

issue with the grading, you may ask your question during instructor's office hours.
- Students are encouraged to read their privacy rights in Family Educational Rights and Privacy Act (FERPA).

Guidelines for Office Hours and Out-of-class Questions

- Students are encouraged to leverage office hours to get the support they need. Some office hours will be held in-person while others will be held via Zoom. Refer to the course page for details.
- Students are required to reserve their location in the queue by signing up using OH Queue.
- During Piazza OH, questions posted before the session will be addressed.
- For example, if Piazza OH is scheduled from 10–11am, then all questions submitted before 10am will be answered during that 10–11am window.
- If you have materials-related questions, you can post them on **Piazza** or ask them during the instructor's office hours. You should plan to receive the question responses on **Piazza** during office hours allocated time.
- You may email personal inquiries and severe emergencies to the instructor(s). The email subject line should begin with **"14-763" or "18-763"**. Emails sent to the instructor should be 2-3 lines maximum and the instructor's response will not be more than few words. Generally, the course instructor is available to respond to personal inquiries during M-F 9am-8pm ET. Please don't expect responses over the weekend or late at night.

Expectations for Class Attendance

- Students are required to follow the schedule of their registered section.
    - Students in the remote section are not expected to attend.
    - Students in the remote section are expected to watch the lecture recording and take the lecture quiz within 24 hours of lecture end time.
- Class attendance and participation are important parts of the learning in this course. To account for this, a portion of the final grade is based on quizzes that are offered during the lectures (see assessment section). That said, I also recognize that students may need to miss class for a variety of reasons (religious observance, job interview, university-sanctioned event, or illness). **For that reason, all students are permitted two class absences (along with their quizzes) without any impact on the final grade.** If you encounter extenuating circumstances and must miss more than two classes, please email the course instructor for further guidance.
- When attending the 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.

Recording of Class Sessions

- Our lectures will be recorded. Please note it may take a few hours for the recording to become available. All lecture recordings will be published on Canvas.

Academic Integrity

- Discussing assignments with your classmates is allowed and encouraged, but it is important that every student gets practice working on these problems. This means that all the work you turn in must be your own. You must devise and write your own solutions and carry out your own tests. The general policy on homework collaboration is:
    - You must first make a serious effort to solve the problem.
    - If you are stuck after doing so, you may ask for help from another student. You may discuss strategies to solve the problem, but you may not look at their code, nor may they spell out the solution step-by-step.

    - Once you have gotten help, you must write your own solution individually. You must disclose, in your GitHub pull request, the names of anyone you got help from.
    - This also applies in reverse: if someone approaches you for help, you must not provide it unless they have already attempted to solve the problem, and you may not share your code or spell out the solution step-by-step.
    - These rules also apply to getting help from other people: friends who are not in the course, homework help websites, Stack Overflow, and so on.
    - You can always, of course, ask for help from the course instructors.
- Students may use generative-AI platforms (e.g., ChatGPT) to assist them with a portion of the homework solution. However, students are expected to cite the text (or code) that was generated from ChatGPT carefully. This includes scenarios where generative-AI was used to generate base-code/scenario and minor (or significant) changes have been made to it.
- You may also use external sources (books, websites, papers, …) to:
    - Look up programming language documentation, find useful packages, find explanations for error messages, or remind yourself about the syntax for some feature,
    - Read about general approaches to solving specific problems (e.g., a guide to dynamic programming or a tutorial on unit testing in your programming language), or
    - Clarify material from the course notes or assignments.
    - But external sources must be used to support your solution, not to obtain your solution. You may not use them to:
        - Find solutions to the specific problems assigned as homework (in words or in code)—you must independently solve the problem assigned, not translate a solution presented online or elsewhere.
        - Find course materials or solutions from this or similar courses from previous years, or
        - Copy text or code to use in your submissions without attribution.
    - If you use code from online or other sources, you must include code comments identifying the source. It must be clear what code you wrote and what code is from other sources. This rule also applies to text, images, and any other material you submit.

- The INI academic integrity policy can be found in the INI Student Handbook http://www.ini.cmu.edu/current_students/handbook/, section IV-C.

- The INI and ECE adhere to Carnegie Mellon University's Policy on Academic Integrity. The policy includes the University expectations around academic integrity and provides definitions of cheating, plagiarism, and unauthorized assistance. A review of the University's Academic Disciplinary Actions procedures is also recommended. These procedures outline the process for investigating, reporting, and adjudicating violations of the University Policy on Academic Integrity, in addition to the appeal process. Students are responsible for reviewing and understanding the University policies listed in the university's handbook:
    - https://www.cmu.edu/student-affairs/theword/

- In addition to the university and college-level policies, it is the INI's policy that an INI student is not permitted to drop the course in which the academic integrity violation occurred. The INI may recommend additional sanctions beyond course-level action. This policy applies, in all respects, to this course.
- Student submissions are validated using Plagiarism-checker.

Student Wellness

- The last few years have been challenging. We are all under a lot of stress and uncertainty at this time. I encourage you to find ways to move regularly, eat well, and reach out to your support system or us (farag@cmu.edu or gqu@andrew.cmu.edu) if you need to. We can all benefit from support in times of stress, and this semester is no exception.

Diversity Statement

- **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.

Food Insecurity

- If you are worried about affording food or feeling insecure about food, there are resources on campus that can help. Any undergraduate or graduate student can visit the CMU Pantry and receive food for free. Follow the directions on the CMU Pantry website to schedule your visit.

Disability Resources

- 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.

Religious Observances

- Students who anticipate conflicts between religious observances and scheduled class activities should notify the instructor by email within the first two weeks of the semester.

Student Academic Success Center

SASC programs to support student learning include the following (program titles link to webpages):

- Academic Coaching: This program provides holistic, one-on-one peer support and group workshops to help undergraduate and graduate students implement habits for success. Academic Coaching assists students with time management, productive learning and study habits, organization, stress management, and other skills. Request an initial consultation here.
- Peer Tutoring: Peer Tutoring is offered in two formats for students seeking support related to their coursework. Drop-In tutoring targets our highest demand courses through regularly scheduled open tutoring

sessions during the fall and spring semesters. Tutoring by appointment consists of ongoing individualized and small group sessions. You can utilize tutoring to discuss course related content, clarify and ask questions, and work through practice problems.

- Communication Support: Communication Support offers free one-on-one communication consulting as well as group workshops to support strong written, oral, and visual communication in texts including IMRaD and thesis-driven essays, data-driven reports, oral presentations, posters and visual design, advanced research, application materials, grant proposals, business and public policy documents, data visualization, and team projects. Appointments are available to undergraduate and graduate students from any discipline at CMU. Schedule an appointment (in-person or video), attend a workshop, or consult handouts or videos to strengthen communication skills.

- Language and Cross-Cultural Support: This program supports students seeking help with language and cross-cultural skills for academic and professional success through individual and group sessions. Students can get assistance with writing academic emails, learning expectations and strategies for clear academic writing, pronunciation, grammar, fluency, and more. Make an appointment with a Language Development Specialist to get individualized coaching.
- Supplemental Instruction (SI): This program offers a non-remedial approach to learning in historically difficult courses at CMU. It utilizes a peer-led group study approach to help students succeed and is facilitated by an SI leader, a CMU student who has successfully completed the course. SI offers a way to connect with other students studying the same course, a guaranteed weekly study time that reinforces learning and retention of information, as well as a place to learn and integrate study tools and exam techniques specific to a course.

Mental Health Resources

- https://www.cmu.edu/wellbeing/resources/timely-care.html
- CaPS has partnered with TimelyCare for provision of virtual well-being services, including immediate emotional support 24/7 as frequently as needed, scheduled appointments with therapists that can be chosen by identity group and other features, health coaching (e.g., sleep issues, weight management, etc.), and group sessions for things like yoga, meditation, etc.

Preliminary Course Schedule (Subject to Change)

Date	Topic	Notes	Instructor
Week-0 (Aug. 11th)	Refresh your Knowledge on Python, Numpy and Unix - Watch provided supplemental recordings	Survey to Test Your Knowledge on Python and Numpy	
Week-1 (Aug. 25th)	- Introduction & Syllabus - System Setup - Dataset Introduction and Business Context - Introduction to the Cloud and Apache Spark	- System Setup HW released	Mohamed
Week-2 (Sep. 1st)	- Data Collection and Storage ● SQL and SparkSQL		Mohamed

Week-3 (Sep. 8th)	- Spark SQL and Data Frames - NoSQL Database	- System Setup HW deadline. - SparkSQL on PostgreSQL HW released. - Course Project Information Released	Mohamed
Week-4 (Sep. 15th)	- Lab: Neo4j AuraDB - Data Streaming	- SparkSQL on PostgreSQL HW deadline. - NoSQL & Kafka homework released	Mohamed
Week-5 (Sep. 22nd)	- Lab: Confluent Kafka - Data Engineering	- NoSQL & Kafka homework deadline. - Data engineering in SparkML homework released	Mohamed
Week-6 (Sep. 29th)	- Data Engineering - SparkML Training and Evaluation	- Course Project Checkpoint	Mohamed/Guannan
Week-7 (Oct. 6th)	- Model Hyper-parameter Optimization - ML Model Selection	- Data engineering in SparkML HW deadline - SparkML HW released	Guannan
Fall Break (Oct. 13th - Oct. 17th)			
Week-8 (Oct. 20th)	- Introduction to Pytorch - SGD & Neural Networks	- SparkML HW deadline	Guannan
Week-9 (Oct. 27th)	- Hyper-Parameter Tuning - GPU Acceleration	- PyTorch HW released	Guannan
Week-10 (Nov. 3rd)	- Distributed Training - Introduction to GenAI	- PyTorch HW deadline	Guannan
Week-11 (Nov. 10th)	- TensorFlow - JAX	- Course Project Deadline - TensorFlow & JAX HW release	Mohamed
Week-12 (Nov. 17th)	TinyML	- TensorFlow & JAX HW deadline - TinyML HW released	Mohamed
Week-13 (Nov. 24th)	TinyML		Mohamed
Week-14 (Dec. 1st)	- ML Model Deployment to the Cloud & MLOps - Final Exam	- TinyML HW deadline	Mohamed