

COURSE SYLLABUS

Semester: Fall 2025

Course Prefix/Number: COT6905

Course Title: Directed Study: Advanced Optimization Algorithms for Large Foundational AI Models

Course Credit Hours: 3.0

Class Meeting Time: Weekly, by appointment

Instructor's Name and Contact Information:

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Course Description:

This directed study investigates the advanced mathematical and optimization foundations required for training and deploying large-scale foundational AI models. The course emphasizes matrix theory as a lens for understanding and improving optimization algorithms, covering topics such as vector spaces, ranks, block operations, and decompositions, as well as tensor factorization techniques relevant to modern architectures. Students will examine stochastic gradient descent (SGD) and adaptive optimizers, study the stability of large-scale training (conditioning, vanishing/exploding gradients), and explore second-order optimization methods, including natural gradient and quasi-Newton approaches.

In addition, the course will connect these mathematical tools to practical model compression strategies – including quantization, pruning, distillation, and low-rank approximations – while also addressing scaling laws, training dynamics, and hardware-aware optimization (e.g., mixed-precision training, quantization-aware training). Students will evaluate models not only on accuracy but also on efficiency metrics such as FLOPs, latency, memory footprint, and energy cost, developing the mathematical and computational background needed to contribute to state-of-the-art research in model compression and efficient large-scale AI.

Topics Covered:

- Matrix theory foundations for deep learning (spaces, ranks, decompositions, low-rank approximations)
- Block matrix multiplications, efficient operations, and tensor factorization
- Stochastic gradient descent (SGD) and adaptive optimizers (Adam, RMSProp, etc.)
- Numerical stability in optimization: conditioning, exploding/vanishing gradients, preconditioning

- Second-order optimization algorithms (natural gradient, quasi-Newton, Fisher-based methods)
- Probabilistic and information-theoretic tools (entropy, KL divergence, variational inference)
- Model compression: quantization, structured/unstructured pruning, knowledge distillation
- Hardware-aware optimization: mixed-precision training, quantization-aware training, deployment considerations
- Scaling laws and training dynamics of large foundational AI models
- Evaluation metrics for efficiency: FLOPs, throughput, latency, memory footprint, and accuracy trade-offs

Course Work:

Students are expected to create an online e-Book that synthesizes the material learned. This e-Book will include simplified explanations of technical content, references to assigned videos, and interactive examples. Additionally, students will develop computational notebooks runnable on Google Colab, organized in a public GitHub repository for reproducibility and community use.

Expected Outcomes:

- Demonstrate mastery of matrix theory concepts as applied to deep learning.
- Explain modern model compression techniques (quantization, distillation, pruning) from a matrix theory perspective.
- Understand the role of advanced optimization algorithms, including second-order methods, in large-scale model training.
- Apply probabilistic and information-theoretic concepts to optimization and compression.
- Produce professional-quality documentation and computational notebooks that communicate advanced concepts effectively.

Grading:

100% – Final e-Book report and GitHub deliverables.

Exams:

There will be no exams for this course. Grades will be based on reports and supplemental deliverables.

Expectations for Academic Conduct/Plagiarism Policy: The [Student Code of Academic Conduct](#) defines various forms of academic misconduct, including cheating and plagiarism, and describes the process for addressing these types of allegations. All students are expected to read the Student Code of Academic Conduct and comply with the expectations. More information and links to the University regulation governing academic conduct can be found on the Dean of Students website, listed under the [Office of Student Rights and Responsibilities](#).

Minimum Technical Skills and Special Technology Utilized by Students: UWF prepares students for current and future business and life applications using basic technology. Each UWF student is expected to do the following:

- Activate a MyUWF student account

- Access the MyUWF portal a minimum of 2-3 times a week
- Access UWF email account (Gmail) 2-3 times a week
- Have basic word-processing knowledge

Student use of UWF information technology resources is governed by the Computing Resources Usage Agreement and the Student Communications Policy. Visit the [Minimum Technical Skills and Special Technology Utilized by Students](#) page for more information on the minimum computer requirements, technical skills, and special technology considerations.

Course Modality: The University of West Florida operations may be disrupted from time to time by weather, pandemics, and other events outside of our control. It is important for faculty and students alike to plan for contingencies that may affect individual course sections. With this in mind, faculty may opt to hold some class meetings in a modality other than that originally planned in order to make certain that the class continues in the best manner possible, given the immediate circumstances. It is important to be flexible and understand that we are operating in a dynamic environment.

TurnItIn: UWF maintains a university license agreement for an online text-matching service called Turnitin. Instructors may use the Turnitin service to evaluate the originality of student papers at their discretion. Instructors can employ other services and techniques to evaluate your work for evidence of appropriate authorship practices as needed. More details can be found in the [UWF Student Handbook](#).

Acceptable and Unacceptable Use of AI:

The use of generative AI tools (e.g., ChatGPT, Dall-e, etc.) is permitted in this course for the following activities:

- brainstorming and refining your ideas
- finding information on your topic
- drafting an outline for your report to organize your thoughts
- developing code snippets to be used in developing a solution for a programming project,
- checking the grammar and style of a report

You are responsible for the information you submit based on an AI query (for instance, that it does not violate intellectual property laws or contain misinformation or unethical content). Your use of AI tools must be appropriately documented and cited to stay compliant with university policies on academic honesty. See these [Citing AI Content](#) resources from the UWF LibGuide: ChatGPT and AI in Higher Education. Any assignment that is found to have used generative AI tools in unauthorized ways will be graded with a zero. When in doubt about permitted usage, please ask for clarification.

Sexual Discrimination or Harassment Reporting: University of West Florida faculty members are committed to supporting students and upholding the university's non-discrimination and harassment policies. Under Title IX, discrimination and harassment based upon sex or gender (including sexual violence and sexual misconduct) are prohibited. If you experience an incident of sex/gender-based discrimination or harassment, you do not have to go through the experience alone. Know that while you may talk to a faculty member, as a "Responsible Employee" of the University, the faculty are required to notify the University's Title IX Coordinator so that support services can be provided to you. If you would like to speak with someone confidentially, you may schedule an appointment with the UWF's Counseling and Psychological Services at (850) 474-2420. This service is free for students. Faculty can also help direct you to, or you may independently access the [University's Title IX website](#).

Civil Discourse: At the University of West Florida, learning involves a variety of ideas, theories, and evidence. The presentation of these ideas does not represent an endorsement of any one idea or perspective. It is vital to the UWF academic mission that we foster an environment that allows for the open exchange of ideas and perspectives to advance the learning objectives for each course. Civil discourse within and outside the classroom is a vital component of the UWF academic environment and is expected of everyone who belongs to the UWF community. Students and faculty may engage with complex ideas in class, and students will often be asked to demonstrate an understanding of the ideas. Understanding an idea, concept, or theory does not require endorsing or agreeing with it but rather hearing and considering its strengths and weaknesses. More information about civil discourse can be found in resources on the [Dean of Students webpage](#).

Health and Safety Protocols: The University of West Florida is dedicated to maintaining the best learning environment possible for our entire community of students, faculty, and staff. We are the University of West Florida. Each of us, and all of us, by the act of stepping onto this campus and into a classroom, accept the responsibility as UWF Argonauts to help make this a safe place to learn. The university will continue to rely on guidance from the Florida Department of Health and the Centers for Disease Control and Prevention to pass on any changes in protocols for health and safety should the need arise. Students are encouraged to consult with their instructors regarding absences and missed work.

Dean of Students: The Dean of Students Office works to create a culture of care by helping students experiencing challenging or difficult life circumstances that might impede academic success. The Dean of Students Office can assist you with academic,

financial, medical, or other extenuating circumstances. Please contact the Dean of Students Office at (850) 474-2384 or email deanofstudents@uwf.edu.

Student Accessibility Resources: The University of West Florida supports an inclusive learning environment for all students. If there are aspects of the instruction or design of this course that hinder your full participation, such as time-limited exams, inaccessible web content, or the use of non-captioned videos and podcasts, reasonable accommodations can be arranged. Prior to receiving accommodations, you must register with Student Accessibility Resources and submit a semester request each semester. Appropriate academic accommodations will be determined based on the documented needs of the individual. For information regarding the registration process, visit the [SAR website](#), email sar@uwf.edu or call 850.474.2387.

Veterans Services: The [UWF Military & Veterans Resource Center \(MVRC\)](#) serves as a leading campus advocate for military and veteran students, working to ensure the needs of these individuals are met through coordinating with multiple university offices and services. The center provides assistance with the following: GI Bill ® education benefits, active duty tuition assistance, out-of-state fee waiver, tutoring, paper reading, counseling, disability accommodations, coordinating academic advising, and referral to state /federal resources and services. The MVRC is located in bldg. 38. For more information on MVRC service, call 474-2550.

Physical Health: All enrolled students have access to The Student Health Clinic, which is a primary care clinic where students can receive medical care or advice. Contact [Student Health Services](#) at (850) 474-2172 for health concerns.

Mental Health Support: At the University of West Florida, we recognize that to learn, thrive, and flourish; you may need a little assistance. Please take advantage of the free resources online or on campus.

- For health concerns, contact Student Health Services at (850) 474-2172.
- For mental health or substance use concerns, contact Counseling and Psychological Services at 850-474-2420.
- For 24/7 crisis counseling, call 850-474-2420 and press option 6.

All students are encouraged to utilize [Therapy Assistance Online \(TAO\)](#) to strengthen skills to cope with anxiety, depression, stress management, and more. TAO is an interactive web-based self-help program that is available 24/7, and access is anonymous.

If you feel like you need somewhere to talk anonymously to others who can support you, peer support is available to all students 24/7 via TogetherAll. TogetherAll is an online community where members are anonymous and can share how they are feeling and support each other. It is an asynchronous program where you can respond to others' posts,

and you can also share your own posts if you would like. Learn more and join TogetherAll at <http://uwf.edu/togetherall>.

Mental Health is one aspect of holistic health, which encompasses all of the eight wellness dimensions. The eight dimensions do not have to be equally balanced. Instead, you should strive to achieve your own authentic personal harmony. You have unique goals, priorities, and aspirations. You determine how to live your best life. ArgoWell is a UWF campus-wide initiative that brings student wellness to the forefront. Learn how ArgoWell can help you make the healthy choice the easy choice and support you in your wellness journey at <http://uwf.edu/argowell>.

Ask-a-Librarian: UWF Library staff are available for help through our [Ask-a-Librarian Live Chat](#), monitored from 8:00 am to 11:00 pm Monday through Thursday, 8:00 am to 4:00 pm on Friday, 9:00 am to 4:00 pm on Saturday, and 9:00 am to 11:00 pm on Sunday. You can also email a librarian using the left-hand navigation in Canvas under Help or Library Tools or text a librarian at 850-483-0225.

Resources: The following resources are available to UWF students and faculty to support academic and research projects:

1. Cybersecurity library resources can be accessed [here](#).
2. [The Writing Lab](#) can help with the projects in this course. Graduate and undergraduate Writing Lab assistants are available to review the mechanics of writing with you and help you upgrade the quality of your papers before you submit assignments.
Note: It may take up to 48 hours or more to receive your work back from the Writing Lab. It is your responsibility to turn your assignment in on time. Take this into consideration when utilizing the Writing Lab.
3. Canvas Support Hotline (Open 24/7) - 1-844-866-3349
UWF ITS Help Desk - 1-850-474-2075 or email itshelpdesk@uwf.edu.
4. The Office of Career Development & Community Engagement (CDCE) offers resume and cover letter reviews, assistance with your job/internship search, interviewing tips, and many other services to assist you in becoming career ready, all at no cost to you! For more information, check out [Handshake](#), visit [CDCE's website](#), or call 850-474-2254

Emergency Information and Course Continuity: In the case of severe weather or another emergency, the campus might be closed and classes canceled. UWF uses a variety of communication methods to alert the campus community about emergency situations and safety threats. [Learn more about Emergency Communications from the UWF Police](#).

Official closures and delays are announced on the UWF website, Mobile Alert, and broadcast on WUWF-FM (88.1MHz).

- Mobile Alert is a broadcasting messaging system utilized by the university in emergency situations. To find more information regarding Mobile Alert, visit the [Enroll in Mobile Alert page](#) or locate the application in MyUWF by searching Mobile Alert.
- WUWF-FM (88.1MHz) is the official information source for the university. Any pertinent information regarding closings, cancellations, and the re-opening of campus will be broadcast.

In the event that hurricane preparation procedures are initiated, the UWF Home Web Page and MyUWF will both provide current information regarding hurricane preparation procedures, the status of classes, and the closing of the university. All students are encouraged to review the [Emergency Procedures Guide](#) as a quick reference for effective and timely action in the event of an emergency.

Other Course Policies

Online Resources: Please explore the UWF Online Campus website to familiarize yourself with online resources (e.g., tips, FAQs). In this course, we will use the *Discord* to distribute course-related resources, and for topic discussions between classes.

Communication: I am available by appointment for any course-related questions you may have. You are responsible for checking your UWF email to keep up with important announcements.

Class attendance: There is no class for this course. Meetings will be held regularly either face to face or online.

Withdraw Policy: For withdrawal deadlines from individual or all registered courses please visit the UWF Academic Calendar posted by the Registrar Office [here](#). Withdrawals after the deadline will result in a grade of *WF* or withdrawal-failing. Applying for an incomplete or *I* grade will be considered only if: (1) there are extenuating circumstances to warrant it, AND (2) you have a passing grade and have completed at least 70% of the course work, AND (3) approval of the department Chair.

Important Note: Any changes to the syllabus or schedule made during the semester take precedence over this version.