CIV E 789 Advanced Topics in Civil Engineering

Fall 2025 - September 03 to December 08

Class time: Friday 11:00AM-1:50PM Location: GSB 7-11

Instructor:

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Office Hours: By appointment via email

Course Description:

*3 (fi) (Fall term, 3-0-0",) Sensors quietly power much of modern engineering and daily life. They turn motion, strain, temperature, and images into digital data that help us understand how systems behave and when they need attention. The same pattern shows up across fields: medical researchers rely on sensors to track physiology, mechanical engineers study machine dynamics, aerospace teams monitor aircraft structures, and structural engineers monitor the condition of infrastructure.
This course follows the complete pathway from planning instrumentation to interpreting data, with an emphasis on bridge engineering applications while drawing connections to other engineering contexts. By the end, Students will learn how to design monitoring strategies, process time-series signals, apply data analytics, and build data-driven models that guide reliable decisions in any engineering system where sensors play a central role.

Prerequisites: Linear Algebra, Statistics, Introductory Structural Dynamics; Basic Python proficiency

Course synchronous and asynchronous content delivery schedule:

Land Acknowledgment:

The University of Alberta respectfully acknowledges that we are located on Treaty 6 territory, a traditional gathering place for diverse Indigenous peoples including the Cree, Blackfoot, Métis, Nakota Sioux, Iroquois, Dene, Ojibway/ Saulteaux/Anishinaabe, Inuit, and many others whose histories, languages, and cultures continue to influence our vibrant community.

TA Information:

TBD

Course Objectives & General Content:

The course provides students with a full view of the monitoring and data analysis process, from designing a sensing plan to interpreting results for reliable decisions. Lectures and labs combine theory with practical examples in bridge health monitoring applications. The course is an important part of the program because it connects fundamental engineering knowledge in mathematics, statistics, and dynamics with modern tools

for sensing and data-driven analysis. It prepares graduate students to apply advanced techniques to their own research and professional practice, and supports interdisciplinary learning across civil, mechanical, and aerospace engineering. Python programming is used throughout the course to connect theory with practice, giving students direct experience with data handling, modeling, and algorithm development.

Learning Outcomes:

By the end of this course, students should be able to:

1. Plan and justify sensing strategies for civil structures, including sensor types and placement.
2. Clean, filter, and prepare time-series data for analysis.
3. Analyze data in the frequency domain using Fourier transforms, spectral analysis, and wavelets.
4. Design and evaluate damage-sensitive features, and perform statistical anomaly detection.
5. Formulate structural health monitoring tasks as optimization problems and apply appropriate solution methods.
6. Apply machine learning approaches such as clustering, and autoencoders for anomaly detection and data augmentation.
7. Develop parametric time-series models and apply Kalman filtering for state estimation.

Marking Scheme:

Activity	(A)Synchronous	Due/Scheduled	Weight
Homework (Sensor Technologies)		September 26 (before class starts)	15%
Research Integration Presentation		TBD (Throughout the Semester)	15%
Project: Report 1		October 10 (before class starts)	15%
Project: Report 2		November 7 (before class starts)	20%
Project: Report 3		November 28 (before class starts)	20%
Final Project Presentation		December 5 (At the time of the class)	15%

Instructors have the leeway to deviate from this average and can assign grades based on their own scheme. All grades are approved by the department chair (or delegate). The office of the Dean has final oversight on all grades.

Term Work

All term work solutions will be posted no later than the last day of classes. All term work will be returned to

students by the final day of classes, with the exception of major term work due in the last week of classes. The latter will be returned by the day of the final examination or the last day of the examination period if there is no final examination in the course as per university policy; instructors will make accommodations to return these term work. It is the responsibility of the student to pick up all their term work at the specified time and place. Any unreturned term work, shall be retained and then shredded six months after the deadline for reappraisal and grade appeals. Final examinations will be kept for one year as required by university guidelines and the Government of Alberta's Freedom of Information and Protection of Privacy Act.

Additional Notes

As per University of Alberta policy, final letter grades will be based on a combination of absolute achievement and relative performance in the class. A minimum grade of C- is required for credit in this course. The following marking scheme will be used:
95% – 100%: A+
85% – 94%: A
80% – 84%: A-
75% – 79%: B+
70% – 74%: B
65% – 69%: B-
60% – 64%: C+
55% – 59%: C
50% – 54%: C-
45% – 49%: D+
40% – 44%: D
Below 40%: F

Calculator Policy

There is no calculator policy in this course; students are free to use the calculator they wish for all assessments.

Expectations for AI use

You are asked to use Generative AI tools in this course. AI use will, however, be dependent on assignment and assessment requirements. Please follow all assessment task-specific directions and guidance as provided. If you have any questions or concerns, please do not hesitate to ask during office hours or after class.
Learning to use AI tools well will take time and practice, so be proactive and set aside some time to 'play' with the AI tools used in this class. Since AI Literacy is an emerging skill (for instructor and student), we will experiment together to discover how best to use them for our academic work and learning.
Familiarize yourself with their strengths and weaknesses. Since many of these tools are prone to fabrication (factual inaccuracies), don't trust its outputs. Assume they may contain errors unless you either know the answer or can confirm it using another source. You will be responsible for any errors or omissions provided by the tool that you fail to identify and resolve.
Important: AI is a tool, but one that you need to transparently and honestly acknowledge using. In addition to standard reference and citation expectations (APA, MLA, etc.), please **always include** a reflective paragraph at the end of any assignment that uses AI. Explain what you used the AI for and what prompts you used to get the results. Failure to do so may be considered an act of cheating and a violation as outlined in the relevant sections of University of Alberta (November 2022) Code of Student Behaviour .
Words of advice: Be thoughtful about when and how you use AI tools for your learning. Don't use them if it isn't appropriate for the use case or circumstance. Don't use them to shortcut the work you need to do to achieve your learning goals.

Text and References (Mandatory):

Course's Live Book (Free): https://mtalebi.github.io/SHM-Live-Book/

Text and References (Recommended):

- Farrar, C. R., & Worden, K. (2013). Structural Health Monitoring: A Machine-Learning Perspective. Wiley.

- Brincker, R., & Ventura, C. E. (2015). Introduction to Operational Modal Analysis. Wiley.

- Chatzi, E. (ETH Zürich). Structural Identification & Health Monitoring (course notes).

- Bianchi, F. M. (2024). Python Time-Series Handbook.

- Söderström, T., & Stoica, P. (1989). System Identification. Prentice-Hall.

Website:

eClass

Did you know that the University of Alberta has various low-to-no-cost services to help students succeed? Visit http://www.deanofstudents.ualberta.ca/ for information about the academic, wellness, and various other support services available to U of A students. It's never too early or too late to seek help!

Course Schedule

Week	Theme	Deliverables / Deadlines
1	Introduction & Motivation	–
2–3	Sensor Technologies	Homework (Sensor Technologies) due Sept 26 (before class)
4	Time-Domain Signal Processing	–
5	Frequency-Domain Analysis	–
6–7	Feature Engineering & Statistical Anomaly Detection	Project: Report 1 due Oct 10 (before class)
8–9	Optimization & System Identification	Project: Report 2 due Nov 7 (before class)
10–11	Machine Learning Applications	–
12–13	Advanced Time-Series Models	Project: Report 3 due Nov 28 (before class) Final Project Presentation Dec 5 (In-person)

University and faculty policies

Respect and professionalism

The Faculty of Engineering is committed to fostering and protecting an equitable, inclusive, and respectful work and study environment in line with University of Alberta policies and professional engineering industry standards.

The faculty prepares students to uphold industry standards to become a Professional Engineer (P.Eng). Therefore, respect, professionalism, and accountability must be upheld within the Faculty of Engineering and the University of Alberta.

Academic integrity and student conduct

The University of Alberta is committed to the highest standards of academic integrity and honesty, as well as maintaining a learning environment that fosters the safety, security, and the inherent dignity of each member of the community, ensuring students conduct themselves accordingly. Students are expected to be familiar with the standards of academic honesty and appropriate student conduct, and to uphold the policies of the University in this respect.

Students are particularly urged to familiarize themselves with the provisions of the Student Academic Integrity Policy and the Student Conduct Policy, and avoid any behaviour that could

potentially result in suspicions of academic misconduct (e.g., cheating, plagiarism, misrepresentation of facts, participation in an offence) and non-academic misconduct (e.g., discrimination, harassment, physical assault). Academic and non-academic misconduct are taken very seriously and can result in suspension or expulsion from the University.

All students are expected to consult the Academic Integrity website for clarification on the various academic offences. All forms of academic dishonesty are unacceptable at the University. Unfamiliarity of the rules, procrastination or personal pressures are not acceptable excuses for committing an offence. Listen to your instructor, be a good person, ask for help when you need it, and do your own work -- this will lead you toward a path to success. Any academic integrity concern in this course will be reported to the College of Natural and Applied Sciences. Suspected cases of non-academic misconduct will be reported to the Dean of Students. The College, the Faculty, and the Dean of Students are committed to student rights and responsibilities, and adhere to due process and administrative fairness, as outlined in the Student Academic Integrity Policy and the Student Conduct Policy. Please refer to the policy websites for details on inappropriate behaviours and possible sanctions.

The College of Natural and Applied Sciences (CNAS) has created an Academic Integrity for CNAS Students eClass site. Students can self-enroll and review the various resources provided, including the importance of academic integrity, examples of academic misconduct & possible sanctions, and the academic misconduct & appeal process. Students can also complete assessments to test their knowledge and earn a completion certificate.

"Integrity is doing the right thing, even when no one is watching." -- C.S. Lewis

The Faculty of Engineering expects an environment free of harassment, discrimination, and bullying. We encourage you to talk to the Office of Safe Disclosure and Human Rights about experiences, questions, or concerns. Additional resources and support for students are attached below.

Engineering students studying in the province of Alberta must also follow the Code of Ethics set by the Association of Professional Engineers and Geoscientists of Alberta (APEGA).

Course outline policies, course requirements, evaluation and grading information can be found in the University Calendar.

Safety during learning activities

In all Faculty of Engineering courses, labs, seminars or other learning activities, safety is of paramount importance. In some cases, laboratory work in a program requires high standards for risk management to keep potential hazards safely under control.

Anyone found to be unable to function safely in the class, lab, seminar or other learning activity may be asked to leave or be removed for their and the safety of other participants and instructors in alignment with the Student Academic Integrity Policy and Student Conduct Policy. As members, or prospective members, of the engineering profession, it is your responsibility to identify and inform the proper authorities of unsafe work.

Audio and video recording

Audio or video recording, digital or otherwise, of lectures, labs, seminars or any other teaching environment by students is allowed only with the prior written consent of the instructor or as a part of an approved accommodation plan.

Student or instructor content, digital or otherwise, created and/or used within the context of the course is to be used solely for personal study and is not to be used or distributed for any other purpose without prior written consent from the content author(s).

Only those items specifically authorized by the instructor may be brought into the exam facility. Students must not bring any unauthorized electronic device into an examination room, including cell phones or other devices.

Student services and support

Health & Wellness Support

Counselling and Clinical Services

Free, short-term, appointment-based counselling and psychiatric services. Also offers drop-in workshops. Book an initial consultation. Visit uab.ca/CCS to learn more.

Wellness Supports Social Workers

Free one-on-one support for students in the areas of housing, finances, academics, personal wellness, life skill development, family dynamics, system navigation, and any area of life where there is a desire to invite change. Visit uab.ca/wellness to learn more.

Sexual Assault Centre

Free, anonymous, and confidential drop-in counselling. Visit uab.ca/UASAC to learn more.

The Office of Safe Disclosure & Human Rights (OSDHR)

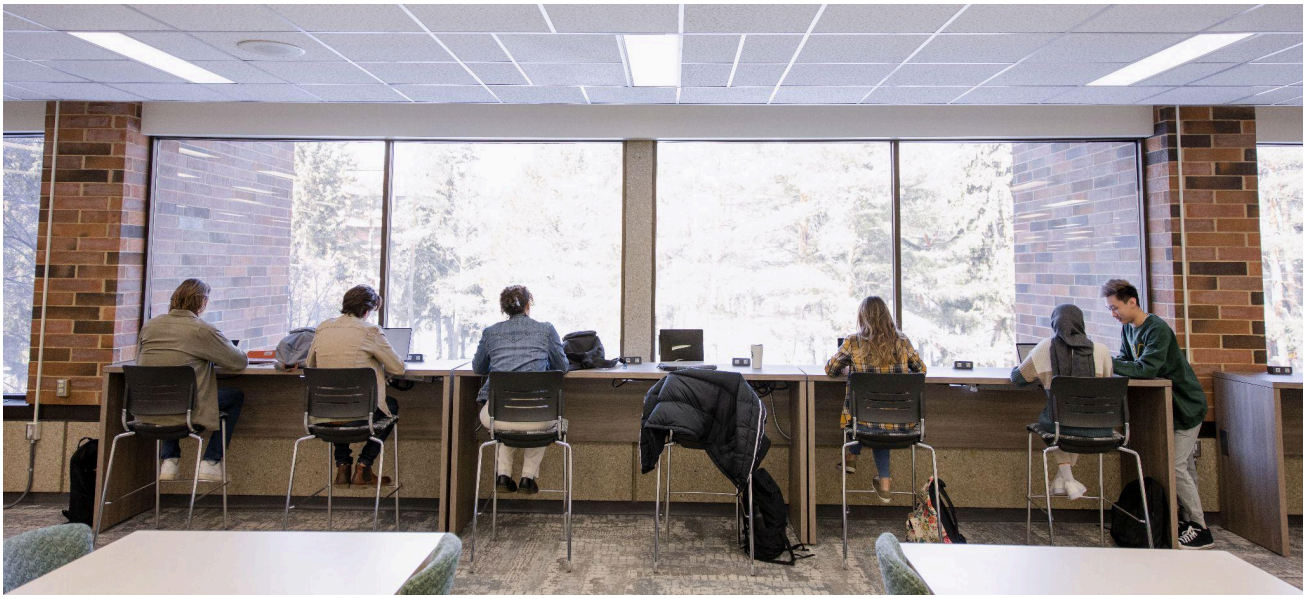
The OSDHR advises confidentially on sensitive issues you may not feel comfortable solving on your own. Contact the OSDHR if you want to get help or to make a report while keeping your privacy. Visit uab.ca/OSDHR to learn more.

HIAR (Helping Individuals at Risk)

If you're worried about someone, contact HIAR, who can help assess risk and connect individuals to support. Learn more at uab.ca/HIAR.

Immediate External Supports

Health Link Alberta: 811
Suicide Crisis Helpline: 988



Academic support

Academic Success Centre
Access to a variety of services to maximize your academic success. Learn more at uab.ca/ASC.

Accessibility Resources
Connects students with disabilities to accommodations. Learn more at uab.ca/Access under accommodations + accessibility.

Decima Robinson Support Centre
Academic support for 100- or 200-level introductory calculus, linear algebra and statistics courses. Visit uab.ca/DSC to learn more.

Engineering Student Success Centre
The Faculty of Engineering provides drop-in tutoring for first-year courses. Visit uab.ca/ESSC to learn more.

Office of the Student Ombuds
Call for complex problems and conflict mediation. Learn more at uab.ca/ombuds.

Financial support

Student Service Centre

For awards and other funding support. Learn more at uab.ca/ask.

Campus Food Bank

The Campus Food Bank Society is an independent charity supporting University of Alberta students, faculty, staff, and alumni for up to five years. For additional information visit their website at campusfoodbank.com.