CIV E 660: ADVANCED STRUCTURAL ANALYSIS

Fall 2025 (September 2nd – December 8th, 2025)

Department of Civil and Environmental Engineering
University of Alberta, Edmonton, Canada

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, Inuit, and many others whose histories, languages, and cultures continue to influence our vibrant community.

Instructor:	Dr. Clayton Pettit	**Lecture Time:**	TR, 2:00 PM – 3:20 PM
Email:	cpettit@ualberta.ca	**Lecture Location:**	GSB 8-11
Office:	DICE 7-230	**Office Hours:**	M, 11:00 AM – 12:00 PM

COURSE DESCRIPTION

CIV E 660 – LEC A3 – 3.0 Units (3-0-0)

Direct stiffness theory and modelling of three-dimensional framed structures. Linear and nonlinear stability concepts. Approximate and direct stiffness formulation of geometric nonlinear problems.

COURSE CONTENT DELIVERY SCHEDULE

All course material will be delivered in person and on campus. If in the unforeseen event that gatherings on campus are prohibited, the lecture material will be delivered and recorded online through Zoom during the scheduled lecture times. If the instructor has fallen ill and/or cannot host the in-person or online lecture, recordings of the lecture will be made available on Canvas.

COURSE OBJECTIVES

Topics to be covered in this course include:

- Governing Equations for Truss and Beam Members
- Beam Theories (Euler-Bernoulli vs. Timoshenko)
- Principle of Virtual Work
- The Stiffness Matrix Method
- Concept and Derivation of Truss and Beam Stiffness Matrices
- Analysis of Truss and Frame Structures
- Special Loading Cases (Settlement, Temperatures, etc.)
- Static Condensation (Element End Releases, Substructure Analysis, etc.)
- Rigidity Constraints
- Commercial Analysis Software (SAP 2000, OpenSees, etc.)

LEARNING OUTCOMES

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

1. Derive and solve the governing differential equations for beams and trusses to determine displacements, internal forces, and stress distributions under applied loading.
2. Compare Euler-Bernoulli and Timoshenko beam theories and justify the appropriate selection for different structural design scenarios based on geometric and loading conditions.
3. Employ the Principle of Virtual Work to solve structural problems involving trusses, beams, and continua and evaluate the accuracy of the resulting approximations.
4. Explain the concepts and procedures underlying the stiffness matrix method and develop computational tools to analyze structures using the stiffness matrix approach.
5. Derive local stiffness matrices for different element types (trusses, beams, frames, etc.) and interpret each matrix component in terms of unit displacements and corresponding reaction forces.
6. Formulate the global stiffness matrix of a structure by transforming and assembling element stiffness matrices from local to global coordinates.
7. Apply the stiffness matrix method to compute structural displacements and extract design-relevant internal forces (axial forces, shear forces, and bending moments).
8. Apply the principles of superposition to incorporate distributed loading, support settlement, and other loading effects within the stiffness matrix method and explain the limitations of superposition.
9. Utilize static condensation to formulate reduced stiffness matrices for elements with end releases and to construct modified global stiffness matrices in substructure analysis.
10. Incorporate rigidity conditions (e.g., axial rigidity, rigid bodies) to reduce the degrees of freedom in a structural system and enable simplified analysis.
11. Account for rigid end zones in frame element models to capture joint stiffness effects and improve the accuracy of structural response predictions.
12. Differentiate between the stiffness matrix method and the finite element method and explain the implications of their respective assumptions, levels of approximation, and typical applications.
13. Use structural analysis software (SAP 2000, OpenSees, ABAQUS) to model and analyze structural systems and explain the underlying analysis procedures these programs perform, including their relevance and limitations in professional engineering practice.

COURSE ASSESSMENTS

Course assessments consist of six equally weighted assignments, a course project, and a final exam. Details for each assessment are provided below.

Assessment	Weight	Due Dates
Assignments	30%	See Course Schedule
Course Project	30%	See Project Description
Final Exam	40%	December 11th, 2025

COURSE WEBPAGE

University of Alberta Canvas Dashboard (canvas.ualberta.ca)

TEXTBOOKS AND RESOURCES

Mandatory:

- None.

Recommended:

- Matrix Structural Analysis (2nd Edition) by McGuire, E., Gallagher, R., and Ziemian, R.
- Matrix Structural Analysis by Sack, R.

ASSESSMENT POLICY

- All assignments and the final exam must be completed individually.
- Assignments must be submitted by the specified due dates (see course schedule below). Late assignments will not be accepted, and solutions will be available after the due date.
- Details on the requirements, deadlines, and submission instructions for the course project are outlined in the Course Project Description document posted on the course Canvas webpage. No late project reports will be accepted.
- The final exam will be closed-book. However, students are permitted to bring a self-prepared, two-page formula sheet and a calculator.
- No make-up final exam will be permitted. If a student misses the final exam, the student must apply for a final exam deferral with the Faculty of Engineering.
- Any suspected violation of academic integrity is required to be reported and may result in disciplinary action as per the Code of the Student Behaviour (available on the course Canvas webpage).
- The use of generative AI tools is permitted only as a supplementary aid (e.g., debugging code, clarifying concepts, etc.). AI must not be used to solve assigned problems directly. All submitted work must reflect your own understanding and effort.

GRADING SCALE

The grade brackets for the course are shown below. Final grades will be assigned based on these fixed thresholds and no curving will be applied.

Letter Grade	Score	Letter Grade	Score
A+	> 95%	C+	60% – 65%
A	87% – 95%	C	55% – 60%
A-	80% – 87%	C-	50% – 55%
B+	75% – 80%	D+	45% – 50%
B	70% – 75%	D	40% – 45%
B-	65% – 70%	F	< 40%

COURSE SCHEDULE

Lecture	Date	General Topic	Lecture Topic
1	Sept. 2nd	Governing Equations	Solid Mechanics Review
2	Sept. 4th		Truss Members
3	Sept. 9th		Euler-Bernoulli Beam Members
4	Sept. 11th		Timoshenko Beam Members
5	Sept. 16th	Virtual Work	Principle of Virtual Work
6	Sept. 18th		Virtual Work for Trusses
7	Sept. 23rd		Virtual Work for Beams
8	Sept. 25th		ABAQUS Software
9	Oct. 7th	Truss Structures	Stiffness Matrix Method
10	Oct. 9th		Truss Elements
11	Oct. 14th		Coordinate Transformations
12	Oct. 16th		OpenSees Software
13	Oct. 21st	Frame Structures	Euler-Bernoulli Beam Elements
14	Oct. 23rd		Frame Elements
15	Oct. 28th		Element Internal Forces
16	Oct. 30th		SAP 2000 Software
17	Nov. 4th	Integrated Load Effects	Concept of Superposition
18	Nov. 6th		Element Loading
19	Nov. 18th		Support Settlement
20	Nov. 20th		Thermal Strains
21	Nov. 25th	Structural Idealization	Element End Releases
22	Nov. 27th		Rigidity Constraints
23	Dec. 2nd		Rigid End Zones
24	Dec. 4th		Substructure Analysis

ASSIGNMENT SCHEDULE

Assignment	Topic	Due Date
1	Governing Equations	Sept. 22nd
2	Virtual Work	Oct. 6th
3	Truss Structures	Oct. 27th
4	Frame Structures	Nov. 10th
5	Integrated Load Effects	Nov. 24th
6	Structural Idealization	Dec. 8th

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

The University of Alberta is committed to the highest standards of academic integrity and honesty. Students are expected to be familiar with these standards regarding academic honesty and to uphold the policies of the University in this respect. All students are expected to follow the University of Alberta's Student Code of Behaviour and Student Conduct Policy. The faculty 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. 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).

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 Code of Behaviour 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 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).

Term Work

All term work 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. It is the responsibility of the student to pick up all of 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 the university guidelines and the Government of Alberta's Freedom of Information and Protection of Privacy Act.

HEALTH AND WELLNESS SUPPORT

Counselling and Clinical Services (uab.ca/CCS**)**

Counselling and Clinical Services provides free, short-term mental health support, including access to counsellors, psychiatrists, and drop-in workshops. If you're struggling or need someone to talk to, they're here to help you take the first step.

Wellness Supports (uab.ca/wellness**)**

Wellness Supports offer free, one-on-one support to help you navigate challenges related to housing, finances, academics, personal wellness, life skills, family dynamics, and more. Reach out if you're facing difficulties or looking to make positive changes in any area of your life.

Sexual Assault Centre (uab.ca/UASAC**)**

The Sexual Assault Centre provides free, anonymous, and confidential drop-in counselling for anyone impacted by sexual violence.

The Office of Safe Disclosure and Human Rights (uab.ca/OSDHR**)**

The Office of Safe Disclosure and Human Rights (OSDHR) advises confidentially on sensitive issues you may not feel comfortable solving on your own. Contact OSDHR if you want to get help or to make a report while keeping your privacy.

Helping Individuals at Risk (uab.ca/HIAR**)**

If you're worried about someone, contact Helping Individuals at Risk (HIAR), who can help assess risk and connect individuals to support.

Immediate External Supports

Health Link Alberta: 811

Suicide Crisis Helpline: 988

FINANCIAL AND ACADEMIC SUPPORT

Office of the Student Ombuds (uab.ca/ombuds**)**

The Office of the Student Ombuds offers confidential support for navigating complex problems, resolving academic or interpersonal conflicts, and understanding your rights as a student.

Student Service Centre (uab.ca/ask**)**

The Student Service Centre can help you with questions about awards, scholarships, and other funding opportunities.

Campus Food Bank (campusfoodbank.com**)**

The Campus Food Bank is an independent charity that provides food support to University of Alberta students, staff, faculty, and alumni (up to five years after graduation).

Academic Success Centre (uab.ca/ASC**)**

The Academic Success Centre offers a range of services to support your academic journey, including help with studying, time management, writing, and more. It also provides accessibility and accommodation resources for students who face barriers to full participation in university life. If you need support or accommodations, they're here to help you succeed in an inclusive and equitable learning environment.