MAE 456 – CAD/Finite Element Analysis

Instructor: Dr. Terence Musho, PhD, PE
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Office Hours: M 1:00–1:50 PM (In-Person or Teams)), W 11:00–11:50 AM (In-Person or Teams)
Lecture: MW 1:00–1:50 PM, ESB G102 **Lab:** M/T 2:00–3:50 PM, ESB-E G78B
TA Office Hours: TBD

Course Description:

This course introduces computer-aided design (CAD) fundamentals and finite element analysis (FEA) through analytical and numerical approaches. Topics include stiffness matrix formulation, vibration analysis, and heat transfer. Practical applications using ANSYS will be explored in design case studies.

Textbooks and Software:

- **Required Textbook:** None
- **Lecture Notes and Recording:** Lecture notes will be scanned and posted on eCampus on Fri every week. Lecture and Lab Recordings will be posted on Collaborate Ultra.
- **Open Education Resource (OER):** Software Demo Videos and eCampus Lecture Recordings
- **Recommended Reference:** *Introduction to Finite Element Analysis and Design*, N. Kim, B. Sankar, and A. Kumar, Wiley, 2018 (Available as ebook WVU Library).
- **Required Software:** MATLAB and ANSYS Student. Students must download and install these programs on personal devices or use campus resources outside of class (e.g., ESB756 MAE Computer Lab). Download the same version of Ansys as installed in computer labs. You may need to select a Prior Release.

Prerequisites:

MAE 342 (or MAE 345) and MAE 343

Required Course Supplies:

- USB drive (minimum 8GB capacity)

Course Delivery

Students may attend in person or join remotely via Collaborate Ultra on eCampus.

Course Objectives:

- Introduce the fundamental concepts of finite element analysis (FEA) for simulation of mechanical systems under prescribed loading conditions.

- Develop skills to model, design, and analyze engineering systems using commercial FEA software.
- Anticipate and avoid failures in mechanical systems, considering professional, legal, and societal consequences.

Student Learning Outcomes:

1. Information Gathering: To introduce the fundamental concepts of the finite element method as a tool for the simulation of a mechanical or thermal system's response to prescribed loading conditions.
2. Make use of Knowledge: To develop students' skills that are necessary to model, design, and analyze engineering mechanical and structural systems of practical significance using commercial FEM software.
3. Judging the Outcome: To predict, anticipate, and avoid failure of mechanical or thermal systems through an understanding of professional, legal, and public welfare consequences caused by those failures.
4. Collaborative Problem-Solving: To foster the ability to work effectively in multidisciplinary teams, encouraging shared responsibility, clear communication, and the integration of diverse perspectives to achieve successful engineering solutions.

ABET Learning Outcomes (ALO) and Student Learning Outcomes (SLO):

ABET Description	ALO	SLO
An ability to apply engineering design to produce solutions considering health, safety, welfare, and global, cultural, social, environmental, and economic factors.	2	1, 2, 3
An ability to function effectively on a team to establish goals, plan tasks, and meet objectives.	3	4
An ability to recognize ethical responsibilities and assess the impact of engineering solutions in societal contexts.	4	1, 3

Grading Breakdown:

Lecture (MAE 456):

- Midterm Exam: 35%
- Final Exam: 35%
- Design Project: 20%
- Lecture Attendance: 10%

Lab (MAE 456L):

- Midterm Exam: 25%
- Final Exam: 25%
- Lab Assignments: 40%
- Lab Attendance: 10%

Final Letter Grades:

- A: 90–100% B: 80–89% C: 70–79% D: 60–69% F: Below 59%

Class Rules

- A professional attitude in class is expected from all students.
- Cell phone use is strictly prohibited during exams. If you are caught using one, you will be asked to leave and will receive a zero.
- Attendance is mandatory and counts toward both lecture and lab grades. Attendance will be recorded using a Google Spreadsheet, which requires logging in with your MIX account.
- Lab assignments will be submitted on eCampus on or before the due date. You will have unlimited submission attempts up to the deadline. You need to preview the submitted PDF for corruption after uploading it to eCampus. PDF format is required. Note: maximum upload size is 15 MB on eCampus. Corrupt files are considered a non-submission.
- All assignments must follow the Lab Report template provided. They will be graded based on the provided Lab Report Rubric. If you submit a lab report with all images and no paragraphs, it will be considered a non-submission.
- Make-up exams will be strongly discouraged and will only be allowed in the event of an excused absence or illness. In these instances, the make-up will be given at the instructor's convenience.
- Completeness, neatness, and legibility in assignments, exams, and projects are mandatory. If I cannot read your writing, you will get zero.
- All assignments will be submitted on eCampus. No assignments will be accepted over email. Email submission will be considered a non-submission.
- No late lab assignments will be accepted. eCampus submission links will close promptly at due dates and times. If you are part of a student project, on a field trip, or become ill, you must notify me before the due date to be granted a late lab submission.
- If you are permitted to submit a late lab report because of excused absences, they may not be graded until the end of the semester.
- Hats must be removed during exams. Book bags need to be zipped and placed under chairs.
- If we have a Guest Lecturer, attendance will be worth ten attendance points.
- ANSYS files may be required to be submitted with assignments, projects, and exam answers. Missing ANSYS result files may result in a zero for an assignment or exam.
- Lab reports and Ansys log files submitted on eCampus will be scanned for uniqueness. Students submitting similar files will be reported to the Office of Academic Integrity.
- If you require accommodations, you must notify me at least seven days in advance so I can make appropriate arrangements with the WVU Student Accommodations Testing Center.

Academic Integrity Statement

The integrity of this course aligns with WVU's Academic Standards Policy. Acts of dishonesty, including cheating and plagiarism, will result in penalties per department and university guidelines. Visit WVU Academic Standards Policy for details.

Inclusivity and Adverse Weather Statements

Inclusivity: WVU is committed to fostering a positive and inclusive learning environment. Students needing accommodations should contact the Office of Accessibility Services.

Adverse Weather: Safety is a priority during inclement weather. Notify the instructor if you are unable to attend class due to weather conditions. I will notify you if I am unable to attend due to weather conditions.

Use of Technology

The use of technology is limited to activities directly related to the course. Inappropriate use will be considered a disruption and subject to WVU's Academic Integrity Policy.

FE Exam Encouragement

Students are encouraged to register for the FE exam this semester. Those taking the exam will be excused from lab assignments during the week prior to the exam date.

Class Schedule:

Week	Lecture Topic	Reading Assignment (Kim and Sankar)
1	Direct Method: Springs and Bars	Chapter 1.1–1.4
2	Uniaxial Bar Element and Thermal Stresses	Chapter 1.5–1.6
3	Plane and Space Trusses	Chapter 1.7
4	Beam and Frame Elements	Chapter 3.1–3.4
5	Buckling of Beams and Frames	Chapter 3.5–3.6
6	Stress and Strain Review	Chapter 5.1–5.4
7	Failure Theories and Safety Factors	Chapter 5.7–5.8
8	Midterm Exam	Covers Chapters 1–5
9	Two-Dimensional Solids: CST Elements	Chapter 6.1–6.3
10	No Class (Fall Break)	None
11	Isoparametric Elements: Formulation	Chapter 7.1–7.2
12	Isoparametric Elements: Numerical Integration	Chapter 7.3
13	Isoparametric Elements: Applications	Chapter 7.4
14	Heat Transfer: Fourier Conduction Equation	Chapter 4.1–4.3
15	Heat Transfer: Two-Dimensional Conduction	Chapter 4.6–4.7
16	ANSYS Theory Manual	Review ANSYS Documentation

Lab Schedule:

Week	Lab Topic	Assignment
1	ANSYS APDL: Rigid Plate and Springs	No Lab Report
2	MATLAB: Rigid Plate and Springs	Lab Report 1: Spring System
3	ANSYS APDL: Truss Element	No Lab Report
4	ANSYS APDL: Beam Element	Lab Report 2: Beam Stress
5	ANSYS APDL: Shell Element	Lab Report 3: Shell Structures
6	ANSYS Discovery: Real-Time Simulation	No Lab Report
7	ANSYS Workbench: Hyperelastic Static Structural	Lab Report 4: Hyperelasticity
8	Midterm Exam	Exam Submission
9	ANSYS Workbench: Contact Surface Transient	No Lab Report
10	No Class (Spring Break)	None
11	ANSYS Workbench: Modal/Harmonic Analysis	Lab Report 5: Modal Analysis
12	ANSYS Workbench: Explicit Dynamic	No Lab Report
13	ANSYS Workbench: Heat Transfer	Lab Report 6: Heat Transfer Simulation
14	ANSYS Workbench: Design Optimization Parameters	Lab Report 7: Parametric Optimization
15	ANSYS Workbench: Topological Optimization	No Lab Report
16	ANSYS Discovery: Fluid Structure Interaction	No Lab Report