PURDUE UNIVERSITY

Fall 2024

CE 570 Advanced Structural Mechanics

Course Information

CRNs: 48967 (On-campus and in-person)
28628 (Off-campus and asynchronous online / Synchronous online available on Zoom)
28660 (On-campus and asynchronous online)

Course credit hours: 3

Meeting days and times: TR 3:00 pm – 4:15 pm in HAMP-2117 + Zoom:
https://purdue-edu.zoom.us/j/94796858972?pwd=TkZ6RGRhODkrZWVxUUxrNzM1ZjZwdz09
Meeting ID: **947 9685 8972**
Passcode: **ce570**

Prerequisites: Graduate Standing; Undergraduate Structural Mechanics;
Multi-variate Vector Calculus, Some Computer Programming (MATLAB)

Instructor(s) Contact Information

Instructor: Dr. Arun Prakash **TA:** Refer to information posted on BrightSpace
Office: HAMP-4119
Email: aprakas@purdue.edu
Office Phone: 765-494-6696

Office Hours: Class Meeting times and Fridays 1pm-3pm in HAMP-4119 and Zoom
Preferred: Post your questions to **Questions & Discussion Forum** on BrightSpace
Or email for an appointment – weekdays, nights and weekends!

Course Description

Studies of stress and strain, failure theories, and yield criteria; flexure and torsion theories for solid and thin-walled members; and energy methods. (See the list of topics for details).

Learning Resources, Technology & Texts

Class Webpage: https://purdue.brightspace.com/

Required textbook: (PDF available through Purdue Libraries)
KD Hjelmstad, Fundamentals of Structural Mechanics, Springer, 2005.

Required Software: MATLAB
Obtain and run MATLAB at Purdue:
https://engineering.purdue.edu/ECN/Support/KB/Docs/MatlabToolboxes
Review 'Getting Started with MATLAB' at:
https://www.mathworks.com/help/matlab/getting-started-with-matlab.html
Complete a 2-hour self-paced crash course (called MATLAB Onramp) at:
https://matlabacademy.mathworks.com/details/matlab-onramp/gettingstarted

Learning Outcomes

Upon completion of the course, students will be able to:

CLO1: Comprehend and utilize mathematical tools to describe problems in structural mechanics
CLO2: Develop mathematical descriptions of deformation of structures
CLO3: Evaluate the state of stress in structural components under different loading conditions
CLO4: Construct relationships between stress and strain for different materials
CLO5: Compute approximate solutions to problems in structural mechanics

List of Topics

1. *Introduction and Mathematical Preliminaries*: Mechanics of solids/structures; Vector algebra; Tensors and matrices; Vector and tensor calculus
2. *Kinematics of deformation*: Deformation map and deformation gradient, rotation and stretch; Strain and physical significance; compatibility;
3. *Stress and equilibrium of deformable bodies*: Free body diagrams; Traction and stress; Equilibrium and balance principles; First and second Piola-Kirchhoff stresses
4. *Material models*: Material frame indifference; objectivity; Hyperelasticity; Isotropy; Hooke's model
5. *Boundary value problems in solid mechanics*: Strong and Weak forms, 1D problems; 2D Plane stress/strain, examples; 3D strong forms and solution methods, examples; Principle of virtual work
   Energy Methods and Variational principles: Directional derivative; Vainberg's theorem
6. *Numerical solutions to boundary value problems*: Ritz method; Introduction to the Finite element method
7. *Structural mechanics of beams*: Kinematic hypothesis; Stress resultants; Planar beam: Timoshenko & Bernoulli-Euler formulations
8. *Structural mechanics of plates*: Kinematic hypothesis; Stress resultants

Course Schedule

- Aug 19 - Aug 25: Week 1 - Ch-1: Parameterization, Scalars, Vectors
- Aug 26 - Sep 01: Week 2 - Ch-1: Indicial Notation, Tensors
- Sep 02 - Sep 08: Week 3 - Ch-1: Change of Basis, Tensor Invariants
- Sep 09 - Sep 15: Week 4 - Ch-1: Calculus on Scalar, Vector and Tensor Fields
- Sep 16 - Sep 22: Week 5 - Ch-2: Deformation Map, Deformation Gradient
- Sep 23 - Sep 29: Week 6 - Ch-2: Polar Decomposition, Areas and Volumes
- Sep 30 - Oct 06: Week 7 - Ch-3: Traction, Stress
- Oct 07 - Oct 13: Week 8 (includes October Break) - Ch-3: Equilibrium
- Oct 14 - Oct 20: Week 9 - Ch-4: Material Behavior, Isotropy
- Oct 21 - Oct 27: Week 10 - Ch-5: Boundary Value Problems
- Oct 28 - Nov 03: Week 11 - Ch-5: Variational Form, Ch-6: Ritz Method
- Nov 04 - Nov 10: Week 12 - Ch-6: Ritz Method, FE Approximation
- Nov 11 - Nov 17: Week 13 - Ch-6: Ritz Method for 2D/3D Problems
- Nov 18 - Nov 24: Week 14 - Ch-6: Ritz Method for 3D Composite Bodies
- Nov 25 - Dec 01: THANKSGIVING
- Dec 02 - Dec 08: Week 15 - Ch-7: (Optional) Theory of Beams

Assignments

Reading: Every week, review posted slides and corresponding sections from the textbook

Videos: Every week, review assigned videos

Online Quiz: Every week, take an online quiz based on the assigned Reading and Videos
Maximum 2 attempts – higher score recorded. Due by **Saturday** of the week.

Homework: Every week, 3 homework problems will be assigned – due in 2 parts:
Part-1: Due by **Saturday** of the week; Solution posted immediately after due date
Part-2: Correct errors and make comments – due by **Saturday of the following week**
Late submissions will not be accepted (unless approved by the instructor in advance).

Projects: During Weeks 1-10: Individual student-led MATLAB project – due in 2 phases:
Phase 1: Students complete the project, prepare slides, record a short video presenting their project, and submit on **Circuit** – due by **Sunday** of the week **Phase 2**: Students conduct a peer evaluation of 3 of their peers and a self evaluation on **Circuit** – due by **Saturday of the following week**
Late submissions will not be accepted (unless approved by the instructor in advance).

Final Project During Weeks 11-15, a final MATLAB-based project will be assigned – due in 2 parts:
Part-1: Stress analysis of an assigned structure – due by Week-13: **Nov-17**
Part-2: Stress analysis of a student-designed structure – due by Week-15: **Dec-8**

4 Live Quizzes Held on Thursdays of **Weeks 3, 6, 9, and 12**: **Sep-5**, **Sep-26**, **Oct-17**, and **Nov-7**.
On-campus students must attend in-person from 3pm – 4:15pm (during class time).
Online students should attend live on Zoom during class time (if possible) or contact the instructor to schedule an alternate 30-minute time-slot in the same week.

Grading Scale

Online Quizzes	20%	(Lowest online quiz score dropped)
Homeworks	20%	(Lowest homework score dropped)
Projects	20%	(Lowest project score dropped)
Final Project	10%	
Live Quizzes	30%	(Lowest live quiz score dropped)
Total	**100%**	

Final grade will be assigned based on the total score in accordance with the following ranges*:

A+ / A / A-	> 90%
B+ / B / B-	80% - 90%
C+ / C / C-	70% - 80%
D	60% - 70%
F	< 60%

* These ranges may be revised up or down when deemed necessary by the instructor.

Attendance Policy

On campus students (CRN 48967) are expected to attend all live meetings in-person.
Online students (CRNs 28628 and 28660) may attend live through Zoom – or review recordings of live class that will be posted to BrightSpace shortly after the class.

Expectation of Time Commitment to the Course

Students with a strong background in the pre-requisites (Undergraduate Structural Mechanics; Multi-variate Vector Calculus; Some Computer Programming in MATLAB) are expected to devote roughly the following amounts of time every week to the different tasks of this course (in that order):

- Reading: 1-2 hours
- Videos: 1-2 hours
- Live class, Office hours: 2-3 hours
- Online Quizzes: 1-2 hours
- Homeworks: 1-2 hours
- Projects: 1-2 hours

Total: 7-13 hours (i.e. about **10 hours per week** on average)

However, if you do not have a strong background in the pre-requisites, then you can expect to spend additional time - especially for the first 3-4 weeks of the semester.

If you believe that you may need help with the pre-requisites, you should reach out to the instructor asap for help and guidance by either:

- posting your concerns on the **Discussion & Questions Forum** on BrightSpace (**preferred**) You may post anonymously, if you wish. However, note that your post will only be anonymous to other students in the class – not to the instructor and the TA.
- Attend office hours
- Schedule a time to meet in-person / Zoom – including weekdays, nights or weekends!

The instructor will try to accommodate all reasonable requests for help with prerequisites as much as possible. Nevertheless, the student is expected to devote the time and effort necessary to remedy any deficiencies in their background.

Academic Integrity

- All work (assignments and exams) that you submit must be strictly **your own work**.
- Obtaining solutions from another student or from any other external source (and/or sharing your work with other students) is **absolutely not allowed**. Nevertheless, collaboration in the form of giving and receiving help on concepts is allowed and encouraged.
- Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing integrity@purdue.edu or by calling 765-494-8778. While information may be submitted anonymously, the more information is submitted the greater the opportunity for the university to investigate the concern. More details are available on our course Brightspace table of contents, under *University Policies*.

Take the Purdue Honor Pledge: "As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue."

Nondiscrimination Statement

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. A hyperlink to Purdue's full Nondiscrimination Policy Statement is included in our course Brightspace under *University Policies*.

Mental Health/Wellness Statement

If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try WellTrack. Sign in and find information and tools at your fingertips, available to you at any time.

If you need support and information about options and resources, please contact or see the Office of the Dean of Students. Call 765-494-1747. Hours of operation are M-F, 8 am- 5 pm.

If you find yourself struggling to find a healthy balance between academics, social life, stress, etc., sign up for free one-on-one virtual or in-person sessions with a Purdue Wellness Coach at RecWell. Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is free and can be done on BoilerConnect.

If you're struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office on the second floor of the Purdue University Student Health Center (PUSH) during business hours. The CAPS website also offers resources specific to situations such as COVID-19.

Accessibility

Purdue University is committed to making learning experiences accessible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247.

Additionally, please refer to the following information on accessibility regarding MATLAB: https://www.mathworks.com/support/accessibility.html

Basic Needs Security

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact the Dean of Students for support. There is no appointment needed and Student Support Services is available to serve students 8 a.m.-5 p.m. Monday through Friday. Considering the significant disruptions caused by the current global crisis as it related to COVID-19, students may submit requests for emergency assistance from the Critical Needs Fund.

Emergency Preparation

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors or TAs via email or phone. You are expected to read your @purdue.edu email on a frequent basis.

In case of an emergency during class time, please refer to the emergency plan for Forney Hall of Chemical Engineering: https://www.purdue.edu/ehps/emergency-preparedness/emergency-plans/bep/building-beps/frny-bep.html

ALL HAZARDS OUTDOOR WARNING SIRENS: immediately seek shelter (**Shelter-In-Place**) in a safe location within closest facility.
FIRE ALARMS: immediately evacuate the building and move to a safe location outside.