ME 722-Advanced Mechanics of Materials
Fall 2022

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Lecture: MWF 12:00-12:50am @ Dolve 204
Office Hours: MWF 10:00-11:00am @ Dolve 208
Course website: https://bb.ndsu.nodak.edu/
Prerequisites: Graduate standing. Students taking this course are assumed to have attended courses in engineering mechanics to the level of Intermediate Mechanics of Materials.

Reference books:

1. *Advanced Mechanics of Materials,* Arthur P. B. and O. M. Sidebottom, John Wiley and Sons, 2003.
2. *Advanced Strength and Applied Elasticity,* A. C. Ugural and S.N. Fenster, 4th edition, Pearson 2008.
3. *Advanced Mechanics of Materials,* R. D. Cook and W. C. Young, MacMillan Publishing, 1985.
4. Advanced Strength and Applied Stress Analysis, by Richard Budynas, 2nd Edition, McGraw Hill, 1999.
5. *Mechanical Behavior of Materials,* N. Dowling, Prentice-Hall, 1993

Zoom Meeting
https://ndsu.zoom.us/j/94255720360?pwd=YnhoQjlNYmRVNHdlZ0o5dlp3QkVOZz09

Meeting ID: 942 5572 0360
Passcode: ME722

ME 722 Bulletin Description:

Advanced Mechanics of Materials is another classical engineering mechanics dealing with stress, deformation and failure analysis of deformable bodies and structures under the application of static and dynamic loadings. The course will cover the fundamental concepts and definitions in stress, strain, energy methods, plasticity, fracture, fatigue, creep, contact, impact and stability of two and three-dimensional solid mechanics as well as plate bending analysis.

Course Aims:

- To provide a comprehensive understanding of the stress and strain analysis of deformable solids and structures.
- To provide a thorough and deep through of governing equations in solving practical engineering problems.
- To explain how the engineering mechanics concepts are applied in a design problem with the background knowledge of failure assessment analysis.
- To become familiar and correlate the important subjects of fracture, fatigue, contact, plasticity and impact mechanics as well as 3D elasticity and flexural mechanics.

Course Objectives:

The purpose of ME722, Advanced Mechanics of Materials, is to provide a thorough understanding of advanced topics concerning the response of materials and structural elements to applied forces of deformation. The course will begin with a thorough explanation of stress, strains and their relations, stress strain transformations in 2D and 3D, and kinematical and compatibility relations. Other closely related subjects to follow will include, proper identification and application and of failure theories, application of energy methods, evaluation of plastic deformation in metals, and fracture and fatigue, contact and impact mechanics. The course will include a chapter on elastic and inelastic buckling and stability of columns. At the end of the course the bending theory for plate problems will be introduced as an introduction to flexural mechanics and the general

theories in plates and shells analysis. The course is expected to give a firm foundation to advanced design topics in engineering mechanics while providing the foundations for analysis of deformable solids for the solutions of complex engineering mechanics problems.

Course Grading:

Students will:
    a.) take tests: midterm, and final exam;
    b.) complete homework assignments on time; and
    c.) Complete a term paper and presentation.
The grades for the course will be determined as follows:

Homework	20%
Term paper	10%
2-Mid-terms	40%
Final Exam	30%
Total	100%

Final course grades will be assigned according to the following scale.

    A 85% or greater
    B 75% to less than 85%
    C 65% to less than 75%
    D 55% to less than 65%
    F less than 55%

Homework: Classical homework problems will be assigned during lectures and posted on the course website. It is essential for the students to do homework problems to learn how to apply the principles of engineering mechanics in practice.

Assignment Submission.
In this course, the Hws will be assigned in Blackboard and should be submitted and uploaded there. You must upload your HW in time, clear, well written and systematic. The images uploaded to Blackboard should be clearly readable and in one file.

Term Paper: The term paper will consist of an exhaustive review of one of the important sub-areas of engineering mechanics and strength of materials on a topic chosen by the student or assigned by the instructor. The paper must be typed, single-spaced, and be no less than 15 pages excluding references. Diagrams, flow charts, figures and tables should be used wherever appropriate for presentation and illustration of the concepts and ideas involved.

Academic Honesty Statement: All work in this course must be completed in a manner consistent with NDSU University Senate Policy, Section 335. Code of Academic Responsibility and Conduct (available on the Web at http://www.dsu.nodak.edu/policy/335.htm). Violation of this code will result in a penalty or penalties to be determined by the instructor to fit the gravity of the offense and the circumstances of the particular case. The instructor may: (1) fail the student for the particular assignment or test, (2) give the student a failing grade in the course, or (3) recommend that the student drop the course.

Attendance: Students should realize that there are materials covered in class which are not discussed in the textbook. The student is responsible for ALL material presented in class whether or not he or she was present in class. If they miss a class, it is the student's responsibility to obtain notes from a classmate. Full credit can be received for work turned in late due to an excused absence. It is the student's responsibility to contact the instructor in such a case. If the student is going to

miss a test for a good reason, he/she should telephone or e-mail the instructor BEFORE the test to arrange for a make-up exam.

Disabilities: Any student with disability who needs accommodations is encouraged to speak with the instructor as soon as possible to make appropriate arrangements for those accommodations.

Health and Safety Expectations

Fall Semester COVID Protocols
Current Status at NDSU Continue to not require masks campus wide.
Faculty members may request that others wear masks in their individual classes.
At the same time, though masks are not required on campus, individuals should feel free to continue wearing a mask based on their individual circumstances.
Consistent with ND Department of Health, we will continue to ask people who are infected or close contacts who are unvaccinated to avoid campus during their five-day isolation period.
Conditions may change during the semester.

Tentative Course Schedule:

Week 1-2:

1. Theories of Stress and Strain Tensors.
Introduction, Definition of Stress and Strain tensors, Transformation of Stresses, Principal Values and Directions, Mean and Deviatoric Stresses, Mohr's Circle for Three-Dimensional Stress and Strains, Strain-Displacement Relations, Strain Transformation, Principal Strains, Small and Finite Strain Theories, Strain and Stresses in Cylindrical Coordinates, Compatibility Relations

Week 3-5:

2. Two-Dimensional Solutions to Problems in Linear Elasticity.
Introduction, Formulation and Methods of Solution, Plane Strain Problems, Plane Stress Problems, Airy's Stress Function, General Solution of Elasticity Problems, Thermal Stresses, Basic Relations in Polar Coordinates, Stress Concentrations, Stresses Due to Concentrated Loads.

Due time for Term Paper selection by students (end of second week)

Week 6-7:

3. Applications of Energy Methods.
Introduction, Work Done in Deformation, Reciprocity Theorem, Castigliano's Theorem, Statically Indeterminate Systems, Principle of Virtual Work, Principle of Minimum Potential Energy, Application of Trigonometric Series, Rayleigh-Ritz Method.

Week 7-8:

4. Thick and Thin-Walled Pressure Vessels
Introduction, Thick walled cylinders and disks, shrink fit problems, Governing Equilibrium Equations, Hook's Law, Governing Equations of Axisymmetric Bodies-Disks, Stresses in hollow disks subjected to rotation, Press and Shrink Fit problems, Thermal stresses- Stresses and deformations due to temperature change only

Mid Term Exam (end of week 8)

Week 9:

5. Curved Beams.
Introduction, Curved Beams under Bending, Rectangular and Circular Cross Section Curved Beams, Winkler Curved Beam theory

Week 10:

6. Unsymmetrical Bending.
Introduction, Combined Stresses in Straight Beams, The General Formula for unsymmetrical bending, Shear Flow in General Form

Week 11:

7. Shear and Torsion of Thin-Walled Members
Introduction, Flow of Shear in Thin-Walled Beams, Distribution of Shear in Thin-Walled Beams, Shear Center

Week 12:

7. Contact and Impact Mechanics
Introduction to Contact Mechanics, Hertzian and non-Hertzian Contact, Method of Computing of Contact Stresses, Point and Line Contacts, Impact and Dynamic Loads.

Week 13-14:

8. Elastic and Inelastic Stability of Columns.
Introduction, Critical Load, Buckling of a Column, End Conditions, Critical Stress in a Column, Buckling of Initially Curved Members, Eccentrically Loaded Columns, Secant Formula, Energy Methods Applied to Buckling, Local Buckling of Columns, Inelastic Buckling of Columns

Week 14-15:

9. Plate Bending Analysis of Plates and Shells.
Basic Assumptions, Strain-Curvature Relations Stress, Curvature, and Moment Relations, Pure Bending of Beams of Symmetrical and Asymmetrical Cross Sections, Governing Equations of Plate Deflection, Boundary Conditions, Simply Supported Rectangular Plates, Axisymmetrically Loaded Circular Plates, Bending Deflections of Rectangular and Circular Plates

Week 16: Dead Week

Term-Paper Presentations by students