ME 725- Spring 2024: Advanced Mechanics and Failure of Composites

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Text: Daniel, I.M., and Ishai, O., *Engineering Mechanics of Composites*, Oxford University Press, 2006.
Prerequisites: Mechanics of Materials
Course Website: **https://bb.ndsu.nodak.edu/**
Lecture: Tu-Th: 9:30 – 11:00am, Dolve 202

Reference books:

1. Reddy, J.N., *Mechanics of Laminated Composite Plates*, CRC Press, 1997.
2. Ting, T.C.T., *Anisotropic Elasticity*, Oxford University Press, 1996.
3. Chou, T.W., *Microstructural Design of Fiber Composites*, Cambridge University Press, 1992.
4. Nayfeh, A.H., *Wave Propagation in Anisotropic Media*, North-Holland Publishing Co., 1995.

Course Bulletin

Concepts in static, dynamics, impact, and thermal analysis of anisotropic elastic materials are covered. Different failure theories, laminated theories, and micromechanics formulations of composites are reviewed in detail.

Course Description:

This is a graduate course, which introduces the micro and macromechanics and failure of composite materials. Concepts in static, dynamics, impact and thermal analysis of anisotropic elastic materials are covered. Different failure theories, laminated theories, and macro/micromechanics formulations of composites would be reviewed in detail. The emphasis will be on methods for determining effective behavior and failure of composites. The course will be mainly concerned with linear behavior although nonlinear behavior of laminates will be referenced. Effective thermomechanical properties, including the elastic and thermo-mechanical properties as well as other characters of multi-phase composites will be discussed.

Course Objective:

Composites are modern engineering materials, which are widely used in different shapes and with different constituents. Mechanical, structural and material engineers should be familiar with analysis as well as with the failure of structures made of such materials. The main objective are to familiarize the students with the main concepts in analysis, design and failure of composite components and structures, as well as thermomechanical experimental procedures especially designed for the determination of mechanical properties of composites. Also, modern computational algorithms associated with design and analysis of such elements will be discussed. This course is designed to introduce the students to the analysis of composite materials from both macromechanical as well as the micromechanical perspective.

Course Outcomes:

1. Students will become familiar and identify the constitutive modelling of composites.
2. Students will be able to identify and derive the effective modelling of composite mechanical properties.
3. Students will understand the nonlinear and viscoelastic behavior and modelling of common composites laminas used in engineering applications.
4. Students will identify the experimental methods for the thermomechanical analysis of composites.
5. Students will design and derive the micromechanics algorithms for composite modelings.
6. Students will become familiar with and optimize the different failure theories associated with composites and laminas.
7. Students will be described the static, dynamic and impact behavior of composites laminas.
8. Students will become familiar with the computational procedures for the analysis of laminated plates.

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Course Grades:

Mid-term & Final Exams	65 points
Homework	15 points
Term Paper	20 points
Total	**100 points**

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

- **A** 85% or greater
- **B** 75% to less than 85%
- **C** 70% to less than 75%
- **D** 60% to less than 70%
- **F** less than 60%

Homework: Problems from the Textbook will be assigned. The due time for the Homework from each chapter will be a week after we finish the related chapter.

Term paper: A term papers should be produced by the student, which will focus on part of the project he/she may be interested or to be assigned. Projects may be computational, theoretical or experimental to typically examine the behavior and characterization of a composite lamina type.

Computer Usage: Students are encouraged to use in one or two homework assigned, the use of the finite element package ANSYS or ABAQUS for the analysis and design laminated structures such as pressure vessels or fuselage. Some homework assignments require the graphical presentation of results in contour plots or other graphics.

American with Disabilities Act for Students with Special Needs Statement

Any students with disabilities or other special needs, who need special accommodations in this course, are invited to share these concerns or requests with the instructor and contact the Center for Accessibility and Disability Services (www.ndsu.edu/disabilityservices) as soon as possible.

Family Educational Rights and Privacy Act (FERPA) Statement

Your personally identifiable information and educational records as they relate to this course are subject to FERPA.

Approved Academic Statement

The academic community is operated on the basis of honesty, integrity, and fair play. NDSU Policy 335: Code of Academic Responsibility and Conduct applies to cases in which cheating, plagiarism, or other academic misconduct have occurred in an instructional context. Students found guilty of academic misconduct are subject to penalties, up to and possibly including suspension and/or expulsion. Student academic misconduct records are maintained by the Office of Registration and Records. Informational resources about academic honesty for students and instructional staff members can be found at www.ndsu.edu/academichonesty.

Attendance:

According to NDSU Policy 333 (www.ndsu.edu/fileadmin/policy/333.pdf), attendance in classes is expected. 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. 4 absences during the semester will be accepted. Absences without excuse and more than 4 will be treated as total absent for the semester and for the grade.

Veterans and student service members with special circumstances or who are activated are encouraged to notify the instructor as soon as possible and are encouraged to provide Activation Orders.

Course Schedule:

Week 1-2
Introduction to Composites Materials
Comparison of Failure Theories in Metals and Composites
Basic Concepts, Materials, Processes and Characteristics

Week 3-6
Elastic Behavior of Composite Lamina, Micromechanics
Elastic Behavior of Composite Lamina, Macromechanics

Mid-Term Exam 1

Week 7-9
Micromechanics Strength and Failure of Unidirectional Lamina
Macromechanics Strength and Failure of Unidirectional Lamina

Week 10-12
Elastic Behavior of Multidirectional Laminates
Hygothermal Effects & Thermal Behavior and characterization of Composites

Mid-Term Exam 2

Week 13-15
Failure Analysis of Multidirectional Laminates
Experimental Methods for Characterization and Testing of Composite Materials
Analysis of Viscoelastic and dynamic Behavior

Week 15-16
Project Presentation

Final Exam

Composites Web Sites:

Name	Web address
American Society for Composites	http://www.asc-composites.org/
Composites World	http://www.compositesworld.com
E-Composites.com	http://www.E-Composites.com/
Worldwide Composites Search Engine	http://www.wwcomposites.com/
The Composites Corner	http://www.advmat.com/
Net-Composites	http://netcomposites.com
Glossary of Composite Terms	http://www.fiberset.com/html/glossary/glos_a.htm
The Composites News Supersite	http://www.compositesnews.com/
Composites Online	http://www.composites.ubc.ca/CompositesOnline/index.asp
About Composites	http://composite.about.com/industry/composite/
SAMPE -the Society for the Advancement of Material and Process Engineering,	http://www.sampe.org/

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